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No. 1670.] *FRIDAY, NOVEMBER* 21, 1884. [*Vol. XXXIII.*

ONE-HUNDRED-AND-THIRTY-FIRST SESSION, 1884-85.

SESSIONAL ARRANGEMENTS.

The First Meeting of the One Hundred and Thirty-first Session of the Society was held on Wednesday, the 19th November, when the Opening Address was delivered by Sir Frederick Abel, C.B., D.C.L., LL.D., F.R.S., Chairman of the Council. Previous to Christmas there will be Four Ordinary Meetings, when papers will be read by Mr. Ernest Hart, Mr. W. H. Preece, F.R.S., Mr. Anton Jurgens, and Mr. P. L. Simmonds.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock. The following dates have been fixed :—

November 26.—Ernest Hart, "The International Health Exhibition."
December 3.—W. H. Preece, F.R.S., "Electric Lighting in America."
,, 10.—Anton Jurgens, "The Preparation of Butterine."
,, 17.—P. L. Simmonds, "Present and Prospective Sources of the Timber Supplies of Great Britain."

For Meetings after Christmas:—

Ralph H. Tweddell, "The Employment of Hydraulic Machinery in Engineering Workshops."

George Clulow, "The History and Manufacture of Playing Cards."

A. J. Ellis, B.A., F.R.S., "The Musical Scales of Various Nations."

Prof. E. Ray Lankester, M.A., F.R.S., "A Marine Laboratory as a Means of Improving Sea Fisheries."

D. Pidgeon, "Labour and Wages in the United States."

Sir J. N. Douglass, "Recent Improvements in Coast Signals."

R. Brudenell Carter, F.R.C.S., "The Influence of Civilisation upon Eyesight."

Prof. H. S. Hele Shaw, "The Evolution of Machines."

Frederick Siemens, "Tempered Glass."

Prof. James Dewar, F.R.S., "The American Oil and Gas Fields.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock:—

January 27; February 24; March 17, 31; April 28; May 19.

APPLIED CHEMISTRY AND PHYSICS SECTION.

The meetings of this Section will take place on the following Thursday evenings, at Eight o'clock:—

February 12; March 12, 26; April 23; May 7, 28.

INDIAN SECTION.

The meetings of this Section will take place on the following Friday evenings, at Eight o'clock:—

January 23; February 20; March 6, 27; April 17; May 15.

CANTOR LECTURES.

Monday evenings at Eight o'clock:—

The First Course will be on "The Use of Coal Gas." By Harold B. Dixon, M.A.

Lecture I.—December 1.—The composition of Coal Gas, its properties, its combustion.

Lecture II.—December 8.—Coal Gas as a source of Light.

Lecture III.—December 15.—Coal Gas as a source of Heat.

The Second Course will be on "Climate, and its relation to Health." By G. V. Poore, M.D.

Lecture I.—January 12.—The chief constituents of Climate, Latitude, Heat, Light, Barometer Pressure.

Lecture II.—January 19.—The effects of Soil, Drainage, and Vegetation upon Climate.

Lecture III.—January 26.—The chief sources of Atmospheric Impurities, both Inorganic and Organic. Climatic Diseases and Climatic Health Resorts.

The Third Course will be on "The Distribution of Electricity." By Prof. George Forbes.

February 2, 9, 16.

The Fourth Course will be on "Artists' Colours." By J. M. Thomson, F.R.S.E., F.C.S., Lecturer on Chemistry at King's College, London.

February 23; March 2.

The Fifth Course will be on "Carving and Furniture." By J. Hungerford Pollen.

Lecture I.—March 9.—Types and Fashions of the Wood Carvers' Art.

Lecture II.—March 16.—The Renaissance.

Lecture III. & IV.—March 23 & 30.—The Age of Gibbons, Boule, and that of their successors.

The Sixth Course will be on "Photography and the Spectroscope." By Capt. W. de W. Abney, R.E., F.R.S.

April 20, 27.

The Seventh and concluding Course will be on "The Manufacture of Toilet Soaps." By C. R. Alder Wright, D.Sc., F.R.S., F.C.S.

Lecture I.—May 4.—Raw Materials. Alkalies; Mineral, Vegetable, and Volatile Alkali. Nature of Animal and Vegetable Fats and Oils. Saponification; chemical changes occurring. Hard and Soft Soaps. Soap-boiling. General characters of manufacturing processes. Cold processes.

Lecture II.—May 11.—Re-melting and Casting. Soap-cutting, Tablet-shaping, Drying, and Stamping. Recent Improvements. Processes not involving re-melting. Transparent Soaps; Alcohol processes; processes not involving the use of Spirit.

Lecture III.—May 18.—Valuations and Analyses of Soaps. Objectionable Constituents. Adulterations. Qualities requisite in Soaps intended for delicate complexions, and infants' skins. Analyses of British and Continental Toilet Soaps, and discussion of their general characters.

HOWARD LECTURES.

Thursday evenings at Eight o'clock :—

A Special Course of Lectures will be delivered under the Howard Trust, on "The Conversion of Heat into Useful Work." By W. ANDERSON, M.I.C.E.

Lecture I.—November 27.—Introduction. The Laws of Motion. Potential and Kinetic Energy. Laws of Impact.

Lecture II.—December 4.—Oscillation, Vibration, Wave Motion, Pulsation in Liquids and Fluids. The Luminiferous Ether. Porosity of Matter; ultimate Structure of matter. Heat the consequence of Molecular Motion. Transparency. Diathermancy. Specific Heat. Unit of Heat. Latent Heat. Absolute Zero of Temperature.

Lecture III.—December 11.—Molecular Theory of Gases. Laws of Volume, Pressure, and Temperature. Isothermal and Adiabatic Lines of Permanent Gases and of Vapours. Joule's equivalent. The doctrines of Carnot. The Limits of Efficiency of Heat-engines.

Lecture IV.—January 22.—The working substances in Heat-engines. Gunpowder Gases. Coal Gas. Hot Air. Steam. The method and cost of preparing the working substances. The theoretical Calorific Power of Fuels, the Degree of Efficiency to be expected, and the Efficiency actually realised.

Lecture V.—January 29.—The Discharge of Artillery; Work done on the Projectile, and on the Gun and Carriage; Limits of Efficiency. Gas-engines; Nature of their Action, Mechanical details, Limits of Efficiency, Results actually obtained.

Lecture VI.—February 5.—Hot Air-engines; Nature of their Action, Mechanical details, Limits of Efficiency. Compressed Air Refrigerating Machines. The Steam-engine, Non-condensing, Condensing, and Compound; Nature of its Action, Mechanical details, Limits of Efficiency, Results actually obtained.

ADDITIONAL LECTURE.

On Tuesday, December 16th, at 4 p.m., B. W. RICHARDSON, M.A., M.D., F.R.S., will deliver a lecture on "The Painless Extinction of Life in the Lower Animals."

JUVENILE LECTURES.

The two Juvenile Lectures will be by PROF. J. NORMAN LOCKYER, F.R.S., on "Universal Time." The dates for these are Wednesday evenings, December 31, 1884, and January 7, 1885. The Lectures will commence at Seven o'clock. Special tickets will be issued to these Lectures.

PROCEEDINGS OF THE SOCIETY.

CHARTER.—THE SOCIETY OF ARTS was founded in 1754, and incorporated by Royal Charter in 1847, for "The Encouragement of the Arts, Manufactures, and Commerce of the Country, by bestowing rewards for such productions, inventions, or improvements as tend to the employment of the poor, to the increase of trade, and to the riches and honour of the kingdom; and for meritorious works in the various departments of the Fine Arts; for Discoveries, Inventions, and Improvements in Agriculture, Chemistry, Mechanics, Manufactures, and other useful Arts; for the application of such natural and artificial products, whether of Home, Colonial, or Foreign growth and manufacture, as may appear likely to afford fresh objects of industry, and to increase the trade of the realm by extending the sphere of British commerce; and generally to assist in the advancement, development, and practical application of every department of science in connection with the Arts, Manufactures, and Commerce of this country."

THE SESSION.—The Session commences in November, and ends in June. The number of Meetings held during the Session amounts to between 70 and 80.

ORDINARY MEETINGS.—At the Wednesday Evening Meetings during the Session papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed.

INDIAN SECTION.—This Section was established in 1869, for the discussion of subjects connected with our Indian Empire. Six or more Meetings are held during the Session.

FOREIGN AND COLONIAL SECTION.—This Section was formed in 1874, under the title of the African Section, for the discussion of subjects connected with the Continent of Africa. It was enlarged in 1879, so as to include the consideration of subjects connected with our Colonies and Dependencies, and with Foreign Countries. Six or more Meetings are held during the Session.

Applied Chemistry and Physics Section.—This Section was formed in 1874, for the discussion of subjects connected with Practical Chemistry and its applications to the Arts and Manufactures. It was enlarged in 1879, so as to include the consideration of subjects connected also with the Applications of Physical Science to the Arts. Six or more Meetings are held during the Session.

Cantor Lectures.—These Lectures originated in 1863, with a bequest by the late Dr. Cantor. There are several Courses every Session, and each course consists generally of from Three to Six Lectures.

Additional Lectures.—Special Courses of Lectures are occasionally given.

Juvenile Lectures.—A short Course of Lectures, suited for a Juvenile audience, is delivered to the Children of Members during the Christmas Holidays.

Admission to Meetings.—Members have the right of attending the above Meetings and Lectures. They require no tickets, but are admitted on signing their names. Every Member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor and other Lectures. Books of tickets for the purpose are supplied to the Members, but admission can be obtained on the personal introduction of a Member. For the Juvenile Lectures special tickets are issued.

Journal of the Society of Arts.—The *Journal*, which is sent free to Members, is published weekly, and contains full Reports of all the Society's Proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce.

Examinations.—Examinations are held annually by the Society, through the agency of Local Committees, at various centres in the country. They are open to any person The subjects include the principal divisions of a Commercial Education, Sanitary Knowledge, Political and Domestic Economy, and Music. A Programme, containing detailed information about the Examinations, can be had on application to the Secretary.

Library and Reading-room.—The Library and Reading-room are open to Members, who are also entitled to borrow books.

Conversazioni are held, to which the Members are invited, each Member receiving a card for himself and a Lady.

MEMBERSHIP.

The Society numbers at present between three and four thousand Members The Annual Subscription is Two Guineas, or a Life Subscription of Twenty Guineas may be paid.

Every Member whose subscription is not in arrear is entitled :—

To be present at the Evening Meetings of the Society, and to introduce two visitors at such meetings, subject to such special arrangements as the Council may deem necessary to be made from time to time.
To be present and vote at all General Meetings of the Society.
To be present at the Cantor and other Lectures, and to introduce one visitor.
To have personal free admissions to all Exhibitions held by the Society at its house in the Adelphi,
To be present at all the Society's *Conversazioni*.
To receive a copy of the Weekly *Journal* published by the Society
To the use of the Library and Reading-room.

Candidates for Membership are proposed by three Members, one of whom, at least, must sign on personal knowledge; or are nominated by the Council. The Annual Subscription is Two Guineas, payable in advance, and dates from the quarter-day immediately preceding election; or a sum of Twenty Guineas in lieu of all further contributions, may be paid.

All subscriptions should be paid to the Secretary, H. T. Wood, and all Cheques or Post-office Orders should be crossed "Coutts and Company," and forwarded to him at the Society's House, John-street, Adelphi, London, W.C.

Proceedings of the Society.

FIRST ORDINARY MEETING.

Wednesday, November 19th, 1884, Sir Frederick Abel, D.C.L., C.B., F.R.S., Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Adams, William, Salisbury-house, Upper Richmond-road, Putney, S.W.
Ainslie, Francis Sawer, Ulverston.
Anderson, A. Hay, 15, Coleman-street, E.C.
Archer, J. A., Waverley, Lordship-lane, S.E.
Ashby, Henry, Staines.
Aubert, William, jun., Crossgates-house, Balham, S.W.
Baker, Arthur Henry, Elderslie, South Eden-park, Beckenham, Kent.
Barlow, Robert, M.R.C.S., Norfolk-house, Dalston, E.
Barrett, C. H., Middleburg, Transvaal, South Africa.
Baxter, Samuel, 18 and 19, Great St. Helen's, E.C.
Beavis, George, 6, Lancaster-road south, Upper Tollington-park, N.
Bell, J. Ferguson, Stafford.
Bemrose, William, Elmhurst, Derby.
Blackham, William Philip, 1, Hyde-park-villas, St. James-road, Wandsworth-common, S.W.
Botting, Francis, 6, Baker-street, W.
Bridgman, Henry Hewitt, 42, Poultry, E.C.
Bright, Charles, 20, Bolton-gardens, S.W.
Bright, Edward Brailsford, 31, Golden-square, W.
Brocklehurst, Septimus, Red Cross-street, Liverpool.
Brown, Harold, Howe-foot, 20, Fitzjohn's-avenue, N.W.
Brownlow, Capt. Arthur, R.N., C.B., Mourne, Beckenham, Kent.
Bryant, William James, Seal, Sevenoaks, Kent.
Buckney, Daniel, Croxton-road, Dulwich, S.E.
Burgess, Henry Edward, 5, Charles-street, Grosvenor-square, W.
Chapman, Edward, M.A., F.C.S., Frewen-hall, Oxford.
Chapman, Henry, Hampton-villa, Upper Harefield-road, Brockley, S.E.
Chappuis, Paul Emile, 69, Fleet-street, E.C.
Cheesman, Walter Nightingale, The Hall, Dulwich, S.E.
Colam, William Newby, 2, Victoria-mansions, Westminster, S.W.
Cooke, Frederick George, Trinity-chambers, Eastbourne.
Cotterill, Prof. James H., F.R.S., 18, Gloucester-place, Greenwich, S.E.
Cox, Edmund Penley, Bahia, Brazil.
Crofton, Lieut-Gen. James, R.E., 12, Westbourne-square, W.
Croyle, James, 38, West-hill, Sydenham, S.E.
D'Alton, Patrick Walter, London Mutual Boiler Insurance Co., 17, Queen Victoria-street, E.C.
Davies, Philip John, 78, Earl's-court-road, Kensington, W.
Dempster, Duncan Ferguson, 4, Glenfinlas-street, Edinburgh.
Devey, Arthur Charles, Lucan-lodge, Clapham-park, S.W.
Devoll, William, 3, Boldmere-road, Erdington, Birmingham.
Dismoor, James Stewart, Stewart-house, Gravesend.
Dougall, Andrew, British Gasworks, Hull.
Duka, Surgeon-Major T., M.D., 55, Nevern-square, S.W.
Eads, James B., 40, West Fifty-third-street, New York.
Eaton, William M., 16, Prince's-gate, Hyde-park, S.W.
Edwards, Col. James Bevan, C.B., York.
Evans, C. J. Mackenzie, 42, Chelsham-road, Clapham, S.W.
Evans, Stanley, 20, Theobald's-road, Bedford-row, W.C.
Falconer, David, 27, Marmora-road, Honor Oak, S.E.
Floyd, Capt. C. Ashburnam, Powys, Eastbourne.
Focking, Mrs. (Anne), 15, Bayswater-terrace, W.
Forester, F. W., Waylands, Beckenham, Kent.
Gale, Miss, 22, Albemarle-street, W.
Galloway, W., The Cottage, Llandaff.
Galt, Hon. Sir Alexander T., G.C.M.G., 79, Cambridge-terrace, Hyde-park, W.
Gemmell, Thomas, 45, Gloucester-street, Warwick-square, S.W.
Gildea, Major James, 20, Phillimore-gardens, Kensington, W., Holme Bury, and Watford, Herts.
Gill, Mason, 21, Commercial-street, Huddersfield.
Goldie, J. Harrison, 7, Temple-street, Swansea.
Gore, John Ellard, Beltra, Ballisodare, Co. Sligo, Ireland.
Green, Walter James, 194, High-street, Watford.
Gunning, Robert Halliday, M.A., M.D., 30, Hazlitt-road, West Kensington-park, W.
Harker, Henry, 37, Walbrook, E.C.
Harris, Henry George, 17 and 18, Upper George-street, Bryanston-square, W.
Harrison, William G., Atherton-house, Birdhurst-rise, South Croydon.
Hassall, Abnor, No. 1, Warehouse, Great Northern Railway, York-road, King's-cross, N.
Hill, William Edward, 37, Stokes-croft, Bristol.
Hovenden, Albert, Oaklands, Haling-park-road, Croydon.
Hutton, Leonard John, Merlewood, Bickley, Kent.
Hutton, Percy Edward Septimus, 6, Newgate-street, E.C.
Inverarity, George, 13, Stanhope-gardens, S.W.
James, Joseph Brindley, M.R.C.S., 47, Jamaica-road, Bermondsey, S.E.

Johnson, Samuel W., Linton-house, The Park, Nottingham.
Jones, H. E., Commercial Gasworks, Stepney, E.
Jones, James, jun., 3, Amersham-park-villas, Park-road, New Cross, S.E.
Kay, Samuel, Charlestown-house, Bramhall - lane, near Stockport.
Kay, Thomas, Moorfield, Stockport.
Kennedy, Prof. Alexander B. W., University College, W.C.
Kennedy, Charles Malcolm, C.B., 27, Kensington-gate, W.
Knill, John, South-vale-house, Blackheath, S.E.
Lammers, Carl Leonhard Herman, 2, Roseworth-terrace, Gosforth, Newcastle-on-Tyne.
Langdon-Down, J., M.D., 81, Harley-street, W.
Langham, James George, Westdown, Eastbourne.
Lavender, H. P., Cleveland Safe and Lock Works, Cleveland-street, Wolverhampton.
Lawder, James Ormsby, Lawderdale, Co. Leitrim.
Lawrence, Frederick W., Oakleigh, Beckenham, Kent.
Lawson, William Taylor, 161, Gresham-house, Old Broad-street, E.C.
Lester, Kenneth Campbell, 12, Saltram-villas, St. Peter's-park, W.
Leon, Arthur Lewis, 34, James-street, Buckingham-gate, S.W.
Lewis, Colonel W. B., R.A., The High Beach, Hollington, near St. Leonards-on-Sea.
Ley, Rev. William Clement, M.A., Ashby Parva Rectory, Lutterworth, Leicestershire.
List, John, 6, Upper St. Germain's-terrace, Blackheath, S.E.
Lockyer, George, 1, Gresham-buildings, Basinghall-street, E.C.
Main, William C., Arundel-house, 70A, Ladbroke-grove, W.
Malpass, John, Abbey-street, Derby.
Marshall, Henry W., 4, Adam's-court, Old Broad-street, E.C.
Martin, Miss Harriet Ann, High School for Girls, Sidney-place, Cork.
Matthews, Henry Thomas, The Mount, Hadley, Barnet.
Montalba, August, 20, Stanley-crescent, W.
Mortimer, Captain Stanley, 7, Observatory-gardens, Kensington, W.
Mullord, Alexander, 99, Mortimer-road, De Beauvoir-square, N.
Ness, Patrick, Kent-house, 1, Lansdowne - road, Notting-hill, W.
O'Callaghan, Guy Morgan Scott, 13, South-square, Gray's-inn, W.C., and Wanderer's Club, S.W.
Odling, William, M.B., F.R.S., 15, Norham-gardens, Oxford.
Ogle, Bertram, Hill-house, Steeple Aston, Oxon.
Ogle, John, 32, Redcliffe-square, S.W.
Ortelli, Chevalier John, 35, Brunswick-square, W.C.
Park, John C., Blenheim-house, Bow-road, Bow, E.
Parkes, James Unitt, Holmwood, Carlton-road, Putney, S.W.
Partridge, W. S., Elmshade, Reigate.
Pocock, Alfred, 233, Southwark-bridge-road, S.E.
Podzus, Jabez, 15, Lamb's Conduit-street, W.C.
Ponsonby, General the Right Hon. Sir Henry, K.C.B., P.C., St. James's-palace, S.W.
Prestige, John Theodore, Hulme-house, Wickham-road, Brockley, S.E.
Price, William Edward, Gas Works, Hampton-wick.
Prince, Henry, 15, Walbrook, E.C.
Purdey, Athol Stuart, 28, Devonshire-place, Portland-place, W.
Râth, Ferdinand, Léontine-villa, Hornsey, N.
Rayner, Thomas Cheveley, Limavady and Dungiven Railway, Limavady, Co. Londonderry.
Read, Richard, Gloucester.
Richardson, Joseph, 15, Fetter-lane, E.C., and 63, Haymarket, S.W.
Roberts, Richard, Grove-road, Clapham-park, S.W.
Robinson, F. R., Atlas Paper Works, Newington-causeway, S.E.
Robson, Bartholemew, Mayfield-lodge, Vanbrugh-fields, Blackheath, S.E.
Rome, William, 158, Cheapside, E.C., and The Red lodge, Putney, S.W.
Rowlett, William Tertius, 34, Newarke - street, Leicester.
Sacré, Alfred L., 60, Queen Victoria-street, E.C.
Salomons, Leopold, 23, Bruton-street, Berkeley-square, W.
Sandars, Samuel, 7, De Vere-gardens, Kensington, W.
Sconce, Gideon Colquhoun, 63, Prince's-square, Bayswater, W.
Scott, Charles Clare, 3, Elm-court, Temple, E.C.
Seton, David Elphinstone, M D., 12, Thurloe-place, South Kensington, S.W.
Seton-Orr, Dr. A. B., 45, Sussex-place, South Kensington, S.W.
Sharpe, Rev. Thomas Wetherherd, M.A., Beddington, Croydon.
Smith, E. Noble, F.R.C.S.E., 24, Queen Anne-street, W.
Smith, George Henry, Park-house, Halifax.
Smith, Josiah, 51, Park-end-road, Gloucester.
Smith, Urban Armstrong, County Surveyor's-office, Hertford.
Spicer, James, J.P., Harts, Woodford, Essex.
Spreckley, Thomas Freer, Freeby, Sidcup, Kent, and 13 and 15, Cannon-street, E.C.
Suffield, Thomas, Farnham, Surrey.
Suft, Charles, Duke of Wellington's Regiment, The Barracks, Tipperary.
Talman, J. J., The Grange, Harbledown, near Canterbury.
Tavener, Stephen N., Great Bedwyn School House, Hungerford.
Taylor, General Sir Alexander, K.C.B., Cooper's-hill, Englefield-green, Surrey.
Thomas, James Lewis, F.S.A., Horse Guards, S.W.

Thomasson, Mrs. (Katherine), 4, Grosvenor-crescent, S.W.
Thorpe, Thomas, 10, Beech-avenue, New Basford, Notts.
Thrupp, Leonard William, 67, Kensington-garden-square, Bayswater, W.
Thurlow, Right Hon. Lord, 33, Chesham-place, S.W.
Topley, W., Geological Survey-office, 28, Jermyn-street, S.W.
Tucker, Miss Mildred Anna Rosalie, 4, Oxford and Cambridge-mansions, N.W.
Turner, Thomas, Saville-town, Dewsbury.
Twelvetrees, Walter Noble, 8, City-road, E.C., and Hargrave-house, Enfield.
Wallace, Robert, H., Rosa, N.W.P., India, and Newton-hall, Kennoway, Fife.
Wallis, Arthur Herbert, Coombehurst, Basingstoke.
Whelpton, Edward Smith, Antron-house, Upper Tulse-hill, S.W.
Wilson, Andrew, Santander, Coventry-road, Streatham, S.W.
Winn, William, 6, Duke-street, Adelphi, W.C.
Wire, Alfred Philip, 1, Seaton-villas, Birkbeck-road, Leytonstone, E.
Wolfsky, Moritz, Kurrachee, High-road, Streatham, S.W.
Wright, Henry Edward, 89, Piccadilly, W.
Wright, William Barton, Balmadies, Prestwich, near Manchester.
Wyman, William Sanderson, M.D., 280, Upper Richmond-road, Putney, S.W.

The CHAIRMAN delivered the following

ADDRESS.

We meet this year to commence the Session on a day with which sad memories are associated in the minds and hearts of members, not only of the Society of Arts, but also of a large number of learned and kindred societies, as well as of a very comprehensive social circle who still deeply mourn the departure of the devoted and trusted friend, the sage and kindly councillor, the genial companion; while the many who were most intimate with his work and his powers have even yet scarcely realised the full extent of the loss which this country and the scientific and technical world at large have sustained by the death of him who was removed from our midst on the 19th of last November.

The unexpected decease of Sir William Siemens on the eve of last Session's commencement deprived you of the customary opening address, upon the preparation of which he was engaged at the time when his brilliant career terminated so abruptly. The previous year he had presented us with a most interesting and valuable discourse, in which he dealt, in his customary lucid and highly suggestive manner, with the position of the question of electric lighting. In that address he called attention to, and illustrated by numerical data, the great cost and practical difficulties which must attend the application of any scheme for lighting a large district from one power centre; but he showed also that electric lighting by incandescence, when carried out on a large scale, is decidedly cheaper than gas-lighting at present prices and with ordinary gas burners; and strongly insisted on the advantages of the electric light, when applied under favourable conditions, over every other source of illumination.

It will be in the recollection of many whom I am addressing that, while Sir William Siemens was an ardent and successful labourer in the advancement of electric lighting, he also maintained the view that gas would continue to hold its own as the poor man's friend; and that, although he regarded the future of gas to be largely dependent upon the development of its use as a heating agent, its economical application as a rival of electricity, in point of brilliancy, received much attention from him during the last few years of his life. The name of Siemens is associated with the origination of a great advance in the application of gas to the brilliant illumination of open spaces; but it must also be conceded that many streets and public places in London and the provinces bear evidence that even such simple modifications in the arrangement of old forms of gas-burners as have been introduced by Sugg and others have restored to gas some of its original prestige, and that, especially in towns where fogs are periodically prevalent, gas is now by no means wholly eclipsed by electricity as an open air illuminant.

In the address intended for presentation to the Society last November—to the partial preparation of which Sir William Siemens devoted considerable time on the last occasion of his visiting his office, a few days after the lamentable fall which determined or accelerated his death—the subject of electric lighting was reverted to; and it was demonstrated by illustrations that, although the sanguine expectations, very generally entertained a twelvemonth previously, of a rapid and almost universal introduction of electric lighting in substitution of other sources of illumination, had not been realised, much had been done in

its application to large edifices and establishments, while even the lighting of domestic dwellings by means of relatively small sources of supply had made some progress. Reference was made to the illustration of the present state of advancement of applied electricity afforded by the International Electrical Exhibition of Vienna, whence our distinguished friend had but recently returned, and it was pointed out that this Exhibition was chiefly remarkable "for the great attention given both by exhibitors and by the examining judges to the attainment of accurate information," and for the interesting display made of measuring instruments. It had obviously been the intention of the writer to devote the chief portion of his address to this most interesting and important branch of applied electric science, and the preparatory remarks on the subject of units of measurement included a very instructive and cogent criticism on the recent action of the Board of Trade, in reference to the normal wire gauge adopted for compulsory use, well worthy the serious attention of those entrusted with the very responsible duty of advising Government in the adoption of important changes of this class.

A reference to the work done by the International Geodetic Congress at its meeting in Rome the previous month, and a sympathetic allusion to the hope expressed by the Congress that England would take another step towards the unification of weights and measures, by joining in the labours of the Metrical Convention established at Sèvres (a hope which has quite recently been fulfilled), concluded the introductory portion of an address which promised to have been one among the most interesting of the many prepared by one of the most highly cultivated and most practical minds of our time.

Those interested in the applications of electricity to practical purposes, as well as all workers in electrical science, have hailed with much satisfaction the final settlement, by the Electrical Congress which met in Paris last April, of the standard of electrical resistance to be adopted for international use, as well as of other important matters relating to electrical units of measurement. The work so auspiciously commenced by the first Electrical Congress, which pursued its labours at the Paris Electrical Exhibition in 1881, has thus been satisfactorily completed. The way had been paved to this settlement of a most important question by laborious scientific research, and it is with pride we now associate the name of Rayleigh and Sidgwick with such illustrious names as Weber, Werner Siemens, Joule, Kirchhoff, Thomson, and with the members of the British Association Committee of 1864, who laid the foundation to the system of electric units now established. The results obtained in different countries by applications of the various means of electrical measurement, which have already attained a high degree of perfection, are now expressed in what may be termed a universal language, the few words of which serve at the same time as monuments to the memory of some of the most illustrious pioneers in electrical science: Volta, Ohm, Ampère, Coulomb, and Faraday. Would that it were in my power to interest and instruct you in the details of the methods of electrical measurement as you would have been had Sir William Siemens lived to complete his address last year. I cannot, however, leave these few words on the subject so incomplete as not to include a reference to the circumstance that the proposal made by him to add to the accepted units one which expresses the rate of doing work by electrical agency, and to give to it the name of Watt, the great master in mechanical science, has been adopted in this country, and will, doubtless, ere long, be universally accepted.

If Sir William Siemens had been spared to meet us here this evening, he would have rejoiced to bear testimony to the continued steady progress made during the past year in the application of the electric light. The brilliantly successful display at the Fisheries Exhibition, to which he made passing allusion in his projected address, has been far outshone by the achievements at the International Health Exhibition, which have surpassed in magnitude any special display or general working installation as yet attempted, both as regards the thoroughly efficient lighting of a very large open and covered area, and of every variety of *locale*, and in respect to special applications of the light, among which unquestionably the most attractive were the beautiful chromatic effects, obtained with transmitted and reflected light, of the fountain-display produced under Sir Francis Bolton's able direction.

A complete account of the arrangements and practical results of the electric lighting at the Exhibition will form a subject for a most interesting and instructive paper, which I trust we may have brought before us during the

present Session; but I cannot forbear giving you a few data, kindly furnished me by Mr. W. D. Gooch, the most able director of the electric lighting at the past two Exhibitions, which illustrate the nature and magnitude of the work accomplished this year.

The space devoted to boilers, motors, and dynamo machines, was, on this occasion, nearly double that alloted to the same purpose at the Fisheries, and there were in all eleven boilers and six engines, with a total of 1306 indicated horse-power. 1,180 tons of coal were used during the Exhibition, which was in the proportion of less than 3·2 lb. per indicated horse-power per hour, the result in one evening's work, with two compound engines, being a consumption of 2·2 lb. per horse-power per hour. The glow lamps, distributed over the Exhibition, exceeded 5,000 in number, there being 2,800 in the Fisheries; and there were 334 arc lights, as against 241 last year. The total area lit by glow lights was 144,462 square feet, and the candle power about 90,000, giving an average of about 0·7 candle to the square foot. The arc lights illuminated an area of 256,808 square feet, with 285,850 candle power, or about 1·125 candle power to the square foot. The obviously great difficulty in estimating the proportion of breakages and failures of lamps, due to accidental causes, renders the formation of even an approximate estimate of the longevity of different lamps used in such an Exhibition, from the collective experience there acquired, very difficult; but while we may hope, within the next few months, to have thoroughly trustworthy data on this head, the practical outcome of the last four months' experience with glow lights at South Kensington has been to show us that there are now eight or nine really trustworthy makers of these lamps; accurate and sufficiently prolonged comparative experiment can alone decide between the relative merits of their productions.

Mr. Gooch has collected some most interesting information with regard to the few temporary failures which occurred in some portions of the installation at the Exhibition, and to their causes, information which will prove of great value to the manufacturers of dynamo machines, and to the organisers and managers of electric lighting arrangements. Altogether, the practical experience acquired in the working of about eighteen different descriptions of dynamo machines for several months, has shown that occasional failures have been due quite as much to the fallibilities of the mechanical accessories as to defects in the machines themselves.

Other electric light installations, upon a much less extensive scale than that at South Kensington, but still of considerable magnitude, have come into operation during the past year; several additional railway stations, theatres, and other public buildings in London and the provinces are now illuminated electrically; arrangements for lighting the New Law Courts throughout are all but complete; and new hotels, and buildings of this class, are now generally arranged to give those using them the benefits in comfort and convenience afforded by the electric light.

While the practical difficulties attending the distribution of power for lighting up an extensive populous district from a large central station, are much what they were when Sir William Siemens explained their nature to us two years ago, the working of small central stations has now for some time past been efficiently carried on in many parts of the kingdom, as exemplified in Mr. Preece's interesting paper of last March.

Among the first in this country to attempt the application of the glow light to the illumination of the dwelling-rooms and offices of a private residence, was the late distinguished President of the Royal Society, Mr. Spottiswoode, whose funeral in Westminster Abbey preceded by a brief period the similar national tribute paid to our late distinguished Chairman. For the large measure of success which has attended the application of the electric light in dwellings, we are primarily indebted to Armstrong, Spottiswoode, Thomson, Crookes, Siemens, and others whose scientific and material resources enabled them readily to grapple with the combination of financial difficulties and of scientific and mechanical problems, which had to be met in the earlier attempts to demonstrate that the working and proper control of an entirely self-contained electric-light installation was within the powers of a domestic establishment, and that electricity could much surpass in efficiency, and perhaps cope in point of economy, with our usual domestic illuminating agents and appliances. Practical electricians, engineers, and architects, have since pursued this tempting subject with much success, and we are indebted to Crompton, Hammond, Tayler Smith, and others, for demonstrating to us, in their own houses, how readily — thanks to the perfection of the gas-engine — the new system of illuminating dwellings may be applied and

maintained, provided a moderate original outlay of capital be judiciously incurred. Most recently our talented Vice-President, Mr. Preece, who, while enlightening us with most interesting discourses, from time to time, on the development of electric lighting, has tried to stem the torrent of enthusiasm called into play by over-sanguine minds and speculative combinations, has devoted himself with his customary ardour to the working out, in his own house, of the problem of combining economy with efficiency in domestic lighting. The many friends whom he has invited to examine his miniature installation, bear hearty testimony to the success with which he has demonstrated how, without the preliminary necessity of a prohibitive expenditure, a moderate householder within reach of gas supply, availing himself of such charmingly simple, safe, and pretty moveable fittings as have been devised by Mr. Tayler Smith, could enjoy the comfort afforded by the glow light in all parts of his small establishment, and could safely entrust the entire management of the lighting of his house to domestic servants of average capacity. Mr. Preece appears to have communicated to our friends in Canada some very interesting results of the experience already acquired by him at home. It is most instructive, both from the scientific and the economic point of view, to learn that, in applying a 2 horse-power gas-engine to work his dynamo-electric machine he obtains 36 ampères current, with an electro-motive force of 42 volts = 1,512 watts, or about 2 horse-power. The actual cost to him of the light, when working, appears to have been fixed by Mr. Preece at about double that of gas; but it is interesting to refer to a statement made by our former chairman, Sir F. Bramwell, during the discussion upon Mr. Preece's communication at Montreal, to the effect that so far as the actual development of light is concerned which the coal-gas consumed by Mr. Preece in driving his dynamo-machine accomplishes, it exceeds by about one-half the light which that gas would yield if used directly as the illuminating agent.

An illustration of the application of water-power to the working of an electric light installation, of about the same magnitude as that which Mr. Preece has established, has recently come under my notice, of which a slight outline may be interesting. A small stream, a feeder of the Teviot, runs through the grounds of an estate near Hawick, and advantage has been taken of it to obtain the power required to illuminate the house and adjoining stables. A turbine has been erected at 350 yards distance from the house, capable of furnishing about 8 horse-power, and requiring 270 cubic feet of water per minute, when working at full power. As the stream does not furnish nearly the required amount in dry weather, a reservoir, in the shape of a lake about an acre in extent, has been constructed in the path of the rivulet; and as the latter furnishes at least 80 cubic feet per minute in the driest weather, the storing of the water during the daytime in dry weather furnishes more than sufficient power to work the turbine when the lights are required. The turbine, housed in a small building, is connected with a Siemens compound self-regulating dynamo machine, capable of working about 70 Swan glow lamps of 16-candle power. About 80 lamps, a few of which are 32-candle power, are fitted up altogether in the house and stables adjoining, and in the avenue leading to the lodge, which is 400 yards from the main building; the latter are controlled by a switch near the hall door, so that they may be lighted up when required. For stopping the turbine at night, a sluice-valve can be closed from the house by means of a simple electrical arrangement. The whole installation is stated to be a good specimen of the class of work which might be carried out at many country houses, where there is a sufficient supply of water-power within convenient distance.

A tendency to exaggerate the danger attending the introduction of electric lighting in houses, and the working of some of the powerful dynamo-electric machines used in connection with large installations, has been encouraged by the occurrence of a few cases of fire in buildings where the fitments have not been executed by properly instructed operatives, or thoroughly inspected by qualified electricians, and of a few fatal accidents, resulting from the employment of inexperienced or heedless men in working machines which engender currents of extremely high electro-motive force. Accidents from the first cause can be effectually guarded against by the careful attention of skilful and experienced constructors to simple regulations, and the probabilities of fire being originated by electric light fittings in houses are certainly small as compared to actual casualties attending the use of gas, petroleum lamps, and other illuminants; while disasters of such extensive nature as have recently attended the display of lamentable ignorance or carelessness in con-

nection with gas-escapes, cannot have their parallel in connection with electric lighting. With respect to the second class of accidents, Mr. Crompton has pointed out that, if the electro-motive force circulated in conducting wires does not exceed 600 volts, neither danger to life, nor injury to health, can result from the careless handling of conductors or parts of a machine, and that, so long as the size of conductors is in ample proportion to the work to be done in large installations, no necessity arises for exceeding the safe limits of what may be termed electrical pressure. The subject of the protection of electric lights from injury due to accidental over-pressure has been successfully dealt with by Mr. Killingworth Hedges and others, and the question of possible danger connected with the application of the electric light on a large or small scale, is not one which should any longer, in the eyes of the public, militate against its adoption.

The improvements which have been made, as shown at the recent Health Exhibition, in the Dowson system of producing gas for heating purposes, the merits of which attracted much attention already at the Paris and Vienna Electrical Exhibitions, have placed at the command of householders residing at a distance from gas-works, convenient and efficient means for the economical working of gas-engines; the electric light is thus placed within the reach of those country residents who are not so fortunately situated as the occupant of the mansion near Hawick to whom I have referred, or as Sir William Armstrong (who was the first to apply water power to electric illumination), or of those who might possibly otherwise be tempted to try and lay up stores of light when the wind blew, by using wind-power, when available, for the charging of a large reserve of storage batteries.

That the successful development of the secondary or storage battery constitutes one essential element to the true solution of the problem of economical lighting of small isolated establishments, was forcibly pointed out to us by Mr. Preece last March; and it is satisfactory, as indicating a continuance of the steady progress in the improvement of secondary batteries which he then recognised, to learn that he contemplates to reap benefit by increasing his battery plant sufficiently to enable him, by charging them only once a week, to lay up a sufficient store of light power to meet his weekly demands.

While the efficiency and value of secondary batteries, as regulators of the electric light, and as temporary sources of supply in the event of an accidental failure for a time in the working of the dynamo machine, have for some time been thoroughly well established, it must still be admitted that, even with the continued improvements which have been effected in their construction and internal arrangement, and with the advantages afforded in this direction by scientific investigation of their action at the hands of several eminent workers, much still remains to be done to reduce tendency to loss of power, and to prolong the life of the secondary battery, before it can in some measure compete with the gas-holder, and equal, in point of economy and portability, its own great merits in other directions. The fact that secondary cells are occasionally produced by different makers which exhibit astonishing efficiency, indicates that, as soon as the conditions which determine this efficiency have been thoroughly traced out and understood, there will be no bar to the attainment of that uniformity in manufacture which is essential to practical success in the electrical storage of energy.

The subject of the possible improvement of primary batteries, with a view to their employment in electric lighting, has received much attention during the past two or three years, and certain modifications of known forms of batteries have achieved some decided success in practical trials in railway carriages, and in connection with small installations of glow lights. So long as the employment of such batteries is confined to cases where dynamo machines are inapplicable, and where, therefore, the question of comparative cost does not force itself to the front, there appears to be a future for the primary battery; but the claims to economy which have been, from time to time, advanced in favour of particular batteries, and which depend in large measure upon the utilisation of the waste products furnished by such batteries, do not appear very likely to be substantiated by practical experience.

With regard to the question what prospect there may be of a reduction in the cost of electric lighting in houses generally, Dr. Hopkinson, in his admirable lecture on electric lighting, delivered before the Institution of Civil Engineers last year, remarked that, while the electrician has no right to look forward to any marked advance in economy in the working of engine and boiler, a considerable reduction in the prime cost of the dynamo-machine might be hoped for. It may be that the conversion of 80 per cent. of the work done

in driving the machine into electrical work outside the machine, is a result which but few of these have yet importantly surpassed, although Dr. Hopkinson himself has recently succeeded in attaining a higher result. It was shown to us, however, by Professor Sylvanus Thompson, last March, that steady and very decided progress had been made, during the past fifteen months, in the construction of machines, a progress which he characterised as of a commercial rather than a scientific order, and which we may, therefore, conclude to have been, in a great measure, in the desired direction pointed out by Dr. Hopkinson.

In the matter of machines for large and small installations, the Health Exhibition presented several interesting examples of the most recent improvements, such as the Siemens machine used for illuminating the fountains, which presented several novelties in detail conducive to economy of power and general efficiency, the large Ferranti alternate current machine for working 1,000 50-volt glow lights; the Edison-Hopkinson and the Hochhausen machines, the Gerard machines for small installations, the Victoria machine (of the well-known Schuckert type), the Leclerc and Burian machine, Bell's unipolar machine, a Burgin machine with Crompton's improvements, and others. A systematic examination of the exhibited dynamos, in reference to the relation borne by the original cost and the cost of working to the amount of light-power realised, and in reference to uniformity, durability, and other working qualities, would have been of great interest; but the difficulties attending the conduct of such an investigation, with machines which are in regular use, are almost insurmountable, and could not possibly be grappled with by the jury who undertook the arduous task of reporting upon the electric light apparatus in the Exhibition. It need scarcely be stated that even an exhaustive comparative examination of arc and glow lights comprises a series of laborious scientific investigations, demanding the application of consummate skill and patient devotion to the work from the hands of experienced electricians, mechanicians, and work with the valuable calculators. The eminent men who undertook the jury work, with the valuable co-operation of Mr. Gooch, have reported upon the merits of electric exhibits as far as lay in their power. They are still pursuing their experiments with the various lights, and it has been decided that this work of the jury should, if necessary, merge into that which will be undertaken in connection with next year's Exhibition of Inventions, as it would be most unfortunate, in the interests of electric lighting as well as of electrical science, if the investigation were not pursued to its completion, so as to admit of the publication of definite results in detail. We have been, up to the present time, doomed to disappointment in our sanguine anticipations of important benefits from the very exhaustive and philosophically conducted series of investigations into the comparative merits of motors, dynamo machines, lights, batteries, and instruments exhibited last year in Vienna, to which, under the presidency of Professor Stefan, of the Vienna University, some of the most eminent physicists and mechanicians of Austria and Germany cheerfully devoted many weeks of unremitting labour. From some combination of causes not easy to comprehend, but a very small proportion of the results of these labours has yet been made public, some few data with respect to glow lights having only just appeared in the "Journal of the Austrian Electro-Technical Society."

Let us hope that the outcome of next year's work in connection with the electric portion of the contemplated Exhibition, and in continuation of the work already accomplished by the late jury, may be the prompt publication of results which will importantly contribute to the further development of electric lighting. A thorough valuation and comparison of the performances of the different and really distinct descriptions of glow light with which we are, or shall become in the next few months, acquainted, will probably constitute almost the most important work of this kind which bears directly upon the advance of the subject; for as it was conclusively demonstrated by Dr. Hopkinson, in the valuable lecture to which I have already referred, the question of a really important reduction in the cost of electric lighting hinges chiefly upon the improvement of the glow lamp. If these lamps, as we now know them, are worked so as to produce an illuminating effect approaching their maximum capability, under which conditions the economy of power is very great, their life is but short. The ordinary practice has been, with the lamps of the types hitherto most generally known, to develop up to 200 candles light-power with one horse-power; it has been possible to obtain with them more than 1,000 candles per horse-power, but not for long. If an improvement could be

realised which would secure the latter result without shortening the life of the lamp, we should at once reduce the cost of the glow lamp light to one-fifth of the previous amount. There is, as Dr. Hopkinson insists, no theoretical bar to such an improvement; indeed, it is probable we may learn from the results of the experiments now in progress with the latest forms of glow lights, including those of Woodhouse and Rawson, Bernstein, Clark and Bowman, and other electricians who have worked much at the subject lately, that decided advances have already been made towards such a result, and considering that the glow lamp is only in the fifth year of its existence, we may have reason to be very hopeful of its future development in the direction of permanence, and of the consequent cheapening of domestic applications of the electric light.

In many directions the convenience and comfort attending the application of the electric light, place the question of cost quite in the background; and in others, where the light has to compete with illuminants other than gas, its superiority from every point of view has been so thoroughly established that it has taken firm root as their substitute. This is notably the case in large passenger ships, where it has been extensively adopted, to the unspeakable convenience and comfort of passengers and crew, and also in our ships of war, where it is, moreover, an indispensable adjunct to naval operations. With respect to military service, the possible advantages to be reaped from the electric light were already recognised at the time of the Crimean war. No actual attempt was made to apply the light during the war, but in 1855, the Ordnance Committee of those days, of which Sir Charles Wheatstone and I were members, purchased, at the suggestion of the latter, some of the earliest form of electric lamps, constructed by the well known French instrument maker, Duboscq, and we carried on a series of night experiments on Woolwich-common, with manœuvreing troops, &c., by the light which was obtained through the agency of a large Bunsen battery. The subject of applying the electric light in connection with military operations has, since that time, received much attention on the Continent as well as from our engineer officers. The light projectors of Colonel Mangin, and of Siemens and Halske, have been known for some years past as efficient and important auxiliaries to the employment of the arc light in field and siege operations, and there were exhibited, both at Paris and Vienna, compact combinations of Gramme and Siemens machines, with Brotherhood motor and boiler, lamp, and projecter, mounted on carriages for military service. The electric light now forms part of the field and siege equipment of our own and other armies, and much important work has been accomplished at the School of Military Engineering, Chatham, in the perfection of our service equipment, more especially by Major Armstrong and Captain Cardew, of the Royal Engineers, who have also rendered valuable service in defining the relative value of dynamo machines available for stationary and portable sources of light, and in organising and devising arrangements for the employment of the electric light as an adjunct to the defence of our military and great commercial harbours by submarine mines.

The applications of electricity in connection with military, land, and submarine mines have now attained a degree of development which places them almost on a footing with the telegraphic appliances of the present day, and any visitor to the Royal Engineer Establishment at Chatham, or the Naval Torpedo School at Portsmouth, must be much impressed by the completeness with which the defence of harbours, passages, and war-ships at anchor, is provided for through the agency of electricity; and this is not only the case with us; thus, one of the most interesting exhibits, in regard to ingenuity, forethought, and completeness of detail, at the Vienna Exhibition, was the collection of apparatus illustrating the operating-room for testing and firing any-one of a very extensive system of submarine mines, and the electrical arrangements in the mines themselves, which was furnished by the Danish Government. The arrangements for the firing of guns, either singly or together, by electricity, in war ships and forts, and the beautiful instruments by which records are obtained of the rate of combustion of a charge of powder in a gun or rifle, of the velocity of its projectile, and of the recoil of the arm or gun carriage, and which have largely contributed to our knowledge of the conditions to be fulfilled by an efficient gunpowder and a really serviceable gun, are but some of the many further interesting illustrations which might be quoted of the intimate connection of applied electricity with the efficiency of our means of offence and defence.

One of the most interesting features of the Paris Exhibition of 1881, was the short length of electric railway exhibited and worked by the Messrs. Siemens; it served to demonstrate

the thorough feasibility of an application of electricity which, in spite of the successful development of the first germ by Werner Siemens, at Berlin, in 1879, had been regarded with much scepticism. Last year we not only saw a much longer line of electric railway, much more extensive and perfect in arrangement, capable of conveying two independent pairs of carriages at one time, constantly in operation between the Vienna Exhibition and the Praterstern, but we also witnessed the opening of an electric railway twelve miles in length between Portrush and Giant's Causeway, an achievement in which Sir William Siemens took great pride; his superintendence of the inauguration was one of the last public acts of his ever busy, useful life.

During the past year, a further illustration of efficient and economical working of a short and light line of railway by electricity has been furnished in England, by the success of the Brighton electric railway, on which, during the past six months, the car mileage has amounted to about 100 miles per diem, the number of passengers carried being in that time about 200,000, the car accommodation being only for thirty persons. The total cost of traction, including interest on capital, depreciation of plant and cost of *personnel*, has, during that period, amounted to 15s. 6d. per diem (100 miles run) or about 2d. per mile.

The detailed plans of a thoroughly matured scheme for an underground electric railway of considerable length, to be applied in Vienna, were shown by Messrs. Siemens at last year's Exhibition; as yet these have not been carried into execution, but some decided progress has been made, both in Austria and Germany, in the development of electrical railways. The experimental Lichtenfeld Railway (about 1·5 miles in length), which was opened in May, 1881, continues in successful operation; two carriages for 20 passengers each are conveyed at the rate of 13 to 18 miles per hour. The Mödling-Vorderbrühl Railway, near Vienna, over $1\frac{3}{4}$ miles in length, was opened last October, five carriages to hold 30 passengers each being run upon it, and travelling at an average speed of ten miles an hour. Lastly, the Sachsenhausen-Offenbach Railway, near Frankfort-on-the-Maine, was opened in April of this year; it is four miles long; the generators are driven by a stationary engine, and eight carriages, each conveying 30 passengers, travel upon it, in couples, at an average speed of $7\frac{1}{2}$ miles per hour. Electric tramways have, moreover, been in regular use for some time past in several important mines in Germany. Thus, at the salt-mines at New Strassfurt there is one 1,200 yards long, on which the locomotives transport 12 ton-loads, at a speed of over six miles an hour.

In the United States, the application of electricity to the working of street railways appears to have been very successfully inaugurated at Cleveland, and we shall, doubtless, receive interesting information concerning this and other items of progress made by our Transatlantic brethren, in developing the applications of electricity, from one or other of our friends who have recently returned from their interesting visits to Canada and the Electrical Exhibition at Philadelphia.

A very interesting account was given to us last winter, by Mr. Reckenzaun, of the history of electric launches, and of the prospects of their further development. The small electrical boat navigated by M. Trouvé on the Seine, during the Exhibition of 1881, in which the motor was worked first by secondary batteries, and afterwards, by means of a bichromate primary battery, may be said to have been the first really practical realisation of the idea to apply electricity to the propulsion of small vessels. A more practical attempt was made a few months afterwards on the Thames, when the Electric Power Storage Company worked a small launch by means of secondary batteries. The launch built for that company by Messrs. Yarrow, for exhibition at Vienna last year, which made many trips on the Danube, with employment of 80 Faure-Sellon-Volckmar accumulators, working a 7 horse-power Siemens' motor, illustrated more fully what could be done in the way of electrical navigation. Quite recently, we have read of a comparative trial between this and another electric launch, and it appears not improbable that there is a future, not merely for the employment of electricity as the motive power of small pleasure craft, but also for working small vessels designed for special services, in which silent progression is an important desideratum, counterbalancing the defect due to the limited period during which the motive power may be maintained. Some formidable difficulties, which I cannot attempt to discuss here, appear, at present, to limit somewhat narrowly the prospect of a successful application of electricity as a motive power on water.

The results which had been obtained in the working out of another system of transport by land, specially designed for the conveyance

of heavy goods at a cheap rate, through the agency of electricity, was brought before us six months ago in a most instructive manner by Professor Fleeming Jenkin, who pointed out that Professors Ayrton and Perry must be regarded as joint originators with himself of the system of electric transmission of weight to which he has given the name of telpherage. The transmission of vehicles by electricity along a single suspended wire or rod, and the utilisation of the result to the economical conveyance of goods, were the problems which Professor Jenkin set himself to solve, and, combining his energies, high scientific talent, practical skill, and ingenuity, with those of Messrs. Ayrton and Perry, who, however, ascribe to him the lion's share of work and credit, he has succeeded in his self-imposed task so thoroughly, that it now only remains for the commercial or manufacturing public to realise the benefits to be derived by utilising the results of his most persevering labours. It must be borne in mind that what Professor Jenkin had set himself to realise, and has accomplished, is not to produce an electric railway for conveying passengers or goods at high speeds, nor in fact to obtain high speed of transmission at all, but to convey trains composed of moderately light trucks, travelling at short distances from each other, and at the ordinary speed of a cart, by distributing the electric power sent into the line or roadway among a number of such trains, the weight of which is distributed along a sufficient length of the road to allow the latter to consist of a rod or rope of metal, say ¾-inch in diameter, upon which the suspended trains travel. After having succeeded in perfecting the details of the wire road along which the suspended trams would run, the electric locomotive and goods trucks composing the small trains and other adjuncts of the system, Professor Jenkin has passed from models of a most perfect description to actual working lines, and having most fairly and conscientiously taken into account all details of outlay incident to the establishment and working of his telpher lines, he has shown that goods can be transmitted, by this system, along a line five miles in length and upwards, with twenty-five trains running at one time, at a speed of four miles an hour, at the rate of a very small fraction over twopence per ton per mile; and along shorter lines, say one mile in length, at the somewhat higher rate of about threepence per ton per mile. As by far the larger proportion of the cost is due to locomotives, trains, stationary dynamos, and motors, the rate per ton per mile for a small traffic does not exhibit a great increase of cost over that of a large traffic, and the traffic upon a line may be increased up to the practical maximum without any fresh outlay upon the line itself. Several simplifications in the details of the permanent way, the locomotives, &c., have been effected since Professor Jenkin brought this interesting subject before the Society; the short working line which was then in existence at Weston will almost immediately be in operation, with some improvements, at Millwall; and I believe that the erection of lines at several works, both in England and Ireland, is now in contemplation; so that we may confidently hope that the reward of practical public appreciation will ere long fitly crown the most untiring labours of Professor Jenkin in this important branch of applied electricity.

The transition from semi-aërial locomotion to the subject of aërial navigation is an easy one; but, while it involves no necessity to let the mind soar to the region of fancies, to picture to oneself the speedy realisation of practical success by the former, it is difficult for the prosaically practical person to persuade himself that we have as yet approached within measurable distance of a really practical solution of that apparently most seductive problem, the propulsion and direction of a balloon. Judging from the proportion which schemes relating to the construction, propulsion, and direction of aërial machines has borne to those of other natures on which, as an official referee in such matters, it has been my melancholy duty in the past thirty years to sit in judgment, this subject appears to possess a fascination quite exceptional, and of a nature tending to etherialise difficulties which, if existing in other directions, would seem, in the present state of our knowledge, well-nigh insurmountable even to the most sanguine inventors.

The first approach to the attainment of some amount of control over an aërial machine appears to have been made by the well-known French engineer, Henri Giffard, who, in September, 1852, made an ascent in a large elongated aërostat, provided with an ingenious combination of sail and rudder, a two-bladed propeller, and a steam-engine and boiler which weighed 330 lb., the additional weight of a supply of fuel and water requisite for a short journey being 1,056 lb. Giffard did not succeed in making any stand against a stiff

breeze that was blowing at the time, but he is said to have demonstrated that he could make his aërial ship obey the rudder. After a second attempt in 1855, Giffard does not seem to have pursued the subject of aërial navigation, though his continued interest in aëronautics was demonstrated by the construction of the gigantic captive balloon, in which thousands ascended in Paris, in 1878, and the gas-generating plant used for its inflation. A new impetus to the application of inventive powers to the subject of aërial navigation was given by the unquestionably important use made of balloons by the French during the siege of Paris.

The well-known engineer, Dupuy de Lôme, devoted much attention, in 1871 and 1872, to the production of machinery for steering balloons, and he was entrusted by the Government during the siege with the construction of an aërostat, which was not tried, however, until February, 1872. The propelling power which was to furnish the means of directing the balloon's course was a screw, which, when worked by eight men in the balloon, gave a velocity of propulsion of about six miles per hour, and De Lôme stated that if worked by a gas-engine or hot-air engine of the same weight as the men, it should have given a rate of propulsion of about 14 miles an hour. The first trial of this aerostat was a failure, as far as the power of steering was concerned, a result ascribed to the prevalence of a stiff breeze. It was eventually demonstrated that, in a dead calm, this balloon could be propelled in a desired direction at the rate of eight miles an hour.

The rapid strides made in the perfection of electric motors when once the success of the dynamo machines had been established by Gramme and Siemens, Edison and Brush, soon led to the production of machines of some power and very small weight and dimensions, the adaptability of which to a variety of special purposes was first demonstrated in a comprehensive manner at the Paris Exhibition. The small motors of Griscom, Deprez, Burgin, and Trouvé, were among the most prominent, and the applications which the latter received included the propulsion of a small boat, and of a miniature aërostat, designed by M. Gaston Tissandier. The motor in the latter, which worked a two-bladed screw, was actuated by the stored power from a Planté secondary battery, weighing only about $2\frac{3}{4}$ lb. This small aerial machine was held captive, but took numerous short flights within the building, and was admired as an interesting toy. It appears, however, that Messrs. Tissandier have since persevered in their attempts to produce a controllable aërostat of useful dimensions; they made the first experiment with their aërial machine last year; it has recently been tried again, with some little promise of success, and the subject has also been perseveringly pursued by two French officers attached to the Military Balloon Establishment at Meudon. The short trip which the Captains Renard and Krebs made in their balloon on the 9th of last August attracted great attention, and the fact that they were enabled successfully to navigate the machine in nearly calm weather, back to the point of departure, from a distance of a few hundred yards, through the agency of a small Gramme motor, was hailed by enthusiasts in aërostation as a conclusive demonstration that the obstacles to veritable aërial navigation had been overcome through the agency of electricity. The dynamo machine constructed for the Meudon aërostat (an elongated structure 27 ft. 6 in. in diameter, and 166 ft. in length), together with its primary battery, stated to furnish 8 horse-power for about four hours, weighed 1,232 lb. The rate of propulsion which was attained on the occasion of the first trial was estimated at nearly twelve miles an hour, and it was hoped to attain the increased speed of about fifteen miles. Only a few days since, it was reported that a second more prolonged journey from Meudon and back had been performed, but details have not yet reached us.

Colonel Beaumont, who is one of our most scientific aëronauts, has expressed the decided opinion that fifteen miles an hour is a low average of the rate of air currents in which even in a calm day, a balloon floats; and that a solution of the problem of aërial navigation will, therefore, only be approached when the balloon can be propelled for some time at a rate of at least fifteen miles an hour. If Messrs. Renard and Krebs have not over-estimated the power at their command, they are at any rate approaching this condition of success.

In the application of balloons to strictly military use, more decided progress towards really practical results have been made. I pass by proposals to employ balloons during campaigns or sieges, when the wind favours, for dropping very large charges of violent explosives among the enemy or on buildings; such contrivances as the so-called dynamite guns, from which large charges of violent explosives are intended to be projected to great distances

through the agency of compressed air, may probably be more likely to achieve some success. It is in the captive condition that the balloon is probably destined to be of decided use in warfare, as affording the power of examining distant districts and of observing the operations of an enemy. A captive balloon was applied to these purposes before Richmond during the civil war in America, and since that time some attention has been almost continuously devoted to the subject of balloons in France, Germany, and in this country.

The importance of reducing, as far as possible, the necessary dimensions of a balloon of sufficient lifting power to carry two men, apart from other practical considerations, necessitates the employment of hydrogen as the inflating agent for a military balloon, and this was not only recognised by the Americans in their work, but it has been the guiding principle here and on the Continent in the attempted organisations of military balloon equipments.

For a number of years I was, from time to time, engaged in association with Royal Engineer officers in endeavouring to elaborate a really efficient method of generating hydrogen in the field, and a readily transportable plant for its production which should not involve the necessity of apparatus and appliances of such bulk and weight as to prohibit their addition to an army equipment. In the skilled hands of Major Templar, at first alone, and subsequently in co-operation with Majors Lee and Elsdale, of the Royal Engineers, the construction of the balloon or gas-bag itself has undergone very considerable improvement in point of gas-retaining power combined with reduction in weight, and many minor details of the captive balloon equipment (of which the telephone is now an important adjunct) have been perfected. But although these officers have also worked perseveringly at the perfection of gas-generating apparatus, much having been also done in that direction at the French balloon establishment at Meudon, it cannot be said that more has been accomplished than the production of fairly efficient arrangements for generating hydrogen, of sufficiently moderate dimensions and weight for ready transport to the base of operations. The means now exist, however, of very readily transporting the prepared gas from that point to any convenient position in the field of operation, in sufficient quantity for inflating a captive balloon there, and for maintaining its buoyancy for considerable periods, by compressing the gas in vessels of steel, which combine comparative lightness with great strength, and are therefore readily transportable, and quite safe to use, even when charged with the gas at a very high pressure. A sufficient number of cylinders charged with the gas at a pressure of about 200 atmospheres, to inflate and maintain the buoyancy of a balloon of 10,000 feet capacity, present a total weight and bulk which may be very readily dealt with on active service. The ease and safety with which very highly condensed gases may be stored in comparatively light vessels, renders it not improbable that this method of storing power may prove at least as susceptible as the storage battery, to the purposes af aërial navigation.

Without venturing even upon the threshold of the great subject of progress in the science and art of war, I may remind the members of the Society of Arts that the foregoing is not the only recent application to war purposes of compressed gases which has resulted from the improvement made in the last few years in steel manufacture, and in the construction of compressing pumps.

It is primarily to the stored power, obtained by the condensation of air in a chamber of light weight, made of the toughest quality of steel, that naval forces owe the efficiency of the locomotive torpedo, elaborated with consummate ingenuity and skill by Mr. Whitehead, of Fiume. This latest engine of war, though as yet its high reputation for evil rests solely upon experimental achievements, is more dreaded than the most formidable artillery, and this dread will even impel naval commanders, when coming to close quarters with an enemy in an action, to resort to the desperate measure of ramming, rather than continue to face the treacherously hidden attacks of these truly infernal machines. You will easily realise the moral effect which may be exercised upon the most courageous by the knowledge that in a naval engagement a ship is never safe, without special precautions difficult to maintain, from the insidious attack of a fish-like monster, gliding noiselessly through the water, being propelled at a rate of twenty-two knots per hour by the working of a most perfect miniature engine, through the agency of air, confined at a pressure of 1,000 lb. to the square inch, and carrying in its head a charge of gun-cotton or dynamite sufficient to sink the strongest warship, if striking her at the comparatively vulnerable part at which it is aimed. A properly fitted torpedo boat, when approaching to within 600 yards of an enemy's vessel, may wound the ship fatally

within three-quarters of a minute from the time that the fish torpedo is started, and if the attack be by day, in smooth water, and with everything most favourable to observation, the only indication afforded of the approach of the messenger of death is the appearance of a streak of air-bubbles upon the water in rear of the machine, as it speeds along at a depth of about ten feet beneath the surface. The accuracy of travel of these torpedoes, under favourable conditions, is remarkable, but, happily, there remain to those liable to be attacked by them two important chances of escape, the one afforded by the reservation conveyed by those words, "favourable conditions," the other, by the great skill, judgment, and experience needed to ensure accuracy of aim, except when operating against ships at anchor, in waters which are perfectly still, or thoroughly well-known to the operators.

It would appear that the Americans are elaborating another application of compressed air to war purposes, namely, the projection, with safety to the operators, of gigantic shells filled with one or other of the most violent explosive agents, to great distances, and at velocities sufficiently high to insure the requisite accuracy of flight, by means of the engine which they style a dynamite gun, and to which I have already referred. Although the firing of shells loaded with gun-cotton, and with some other violent explosives, from particular guns, may now be accomplished without risk of the shell-charge being exploded by the concussion produced in firing the gun, there remain several elements of uncertainty in applying such shells, which may at any time jeopardise the safety of those using them, or of the guns firing them. Hence the perfection of an engine for accomplishing the object for which the dynamite gun is designed, is likely to constitute a formidable addition to the resources of belligerents, and another important application of stored force in the shape of compressed gas.

The condensation of hydrogen, oxygen, laughing gas, and carbonic acid in small receptacles of wrought iron or steel, so that considerable supplies of these gases under controllable pressure are available at any moment, has for some years past been carried on commercially to the great advantage of the experimental sciences, of surgery and dentistry, and of many who avail themselves of the oxy-hydrogen light for purposes of instruction, entertainment, or spectacular effect. The facilities for producing great cold by allowing liquefied carbonic acid to escape, and utilising the frozen gas obtained in consequence of the great depression of temperature caused by the sudden evaporation of portions of the escaping liquid, have been in times past applied by some of the most illustrious physicists and chemists to the liquefaction and solidification of certain gases which, within the memory of some present, were called permanent gases. Even nitrogen, hydrogen, and oxygen, have had to yield the position they maintained until quite lately as uncondensable gases. The relations between the solid, liquid, and gaseous states of matter have been made thoroughly clear to us and there are many other achievements of great interest and moment to the student, and to the advancement of science, which have to be primarily ascribed to the liquefaction of carbonic acid. In earlier days the time, labour, and uncertainty attending the preparation of liquid and solid carbonic acid in small quantities were considerable; I have myself a lively recollection of the expenditure of much time and energy in my student's days upon the attainment of comparatively insignificant results, with the small apparatus of Thilorier and of Natterer. The facility with which the experimentor may now avail himself of liquefied carbonic acid upon a large scale, was illustrated in a remarkable manner by the memorable series of experiments which Prof. Dewar displayed to the members of the Royal Institution last June, and repeated before His Royal Highness our President and the Princess, in the course of which that accomplished chemist clearly exhibited to a large audience the liquefaction of oxygen gas by the method due to the young Russian physicist Wrobrewski. Solid carbonic acid in solution with ether was, in the first instance, employed to produce, in a rarefied atmosphere, a temperature of about —115° Centigrade, and by the application of this refrigerating agent, the highly illuminating component of coal-gas known as ethylene was liquefied. By obtaining this liquid in sufficient quantities, and allowing it in turn to evaporate rapidly in a rarefied atmosphere, a temperature of from —140° to —150° Centigrade was reached, whereby oxygen, exposed to this intense cold under a pressure of from 20 to 30 atmospheres, was reduced to the liquid form. Dewar has found that solid carbonic acid, and especially liquefied or solid nitrous oxide, may be used for liquefying oxygen without the intervention of ethylene, and that liquefied marsh-gas will probably prove the most suitable agent

for producing extremely low temperatures; meantime Wrobrewski and his former coadjutor Olzewski have been, during the past year, applying liquefied oxygen to the ready liquefaction of hydrogen, nitrogen and air, and to the attainment of most important additions to our knowledge of the physical properties of the quondam permanent gases, whereby they have eclipsed the achievements of Pictet and of Cailletet, which surprised the scientific world a few years ago.

The comparatively remarkable facilities with which the experimentor can now avail himself of liquefied carbonic acid as the starting-point in the attainment of very low temperatures, is well illustrated by the fact that to achieve the results exhibited by Professor Dewar at his lecture on an exceedingly hot night in June, he had to expend no less than five gallons of the liquefied gas. This supply had been manufactured according to the system of Dr. Raydt, by Dr. Kühnheim, of Berlin, and sent over thence in the large wrought-iron cylinders in which the gas is condensed.

It is not only science, however, that benefits now by the facility with which liquefied carbonic acid is manufactured in Germany. As a most convenient source of power, it has received several important applications. Thus, Messrs. Krupp, the celebrated steel makers at Essen, who produce the liquefied gas upon a large scale for their own purposes, have, during the past three years, employed it extensively for maintaining steel castings under pressure, during the solidification of the metal, by closing the mould directly the metal is cast, and then allowing the liquefied gas to escape from a reservoir connected with the mould, whereby the space above the molten metal becomes filled with gas under very high pressure. This is maintained until the steel is completely solidified, all tendency to formation of cavities being thus avoided. This system of casting is now being applied to other metals and alloys. In proof of the absence of danger in employing liquefied carbonic acid, it may be mentioned that Messrs. Krupp keep the reservoirs of the liquid immersed in hot water when using it, in order to add to, and maintain uniformity of, pressure during the employment of the condensed gas. The stored force presented by the liquefied gas has received further useful applications, such as for the working of fire-extinguishing apparatus, and, upon a very extensive scale, in Berlin and various parts of Germany, for forcing beer from casks, placed underground or at any distant point, to the place where it has to be drawn. Not only is this mode of raising and transferring beer very simple and efficient, but it also presents the important advantage of completely excluding air and its concomitant impurities from the casks and conduit pipes, the beer being thereby protected from contamination, and prevented from becoming sour, whilst its briskness is maintained by its continuous contact, under slight pressure, with the very kind of gas which beer becomes charged with during the brewing, and which imparts the agreeable briskness to beer in good condition.

Liquefied carbonic acid has not yet been produced upon an extensive scale in England, and its importation from Germany has been impeded—indeed, altogether arrested—by the very causeless alarm which the issue of an authoritative caution has raised, as to possible danger to ships or trains conveying the cylinders of compressed gas. It is to be hoped that we shall not long be unnecessarily debarred from participating in the benefits derivable from the application of liquefied carbonic acid; benefits which, from a hygienic point of view alone, are very substantial, and which therefore cannot fail to be appreciated, especially after the teaching received by us at the recent Health Exhibition. That teaching, which cannot fail to prove fruitful of great benefit to the country, presents features of special interest to members of the Society of Arts, and is, therefore, a subject upon which I may be permitted to dwell briefly before concluding these very discursive remarks.

In the early days of this year's Exhibition, the question was frequently asked of those who had been entrusted with its development and arrangement, What has the Exhibition to do with health? And, indeed, a visitor, in passing down the large gallery which faced him as he entered, found himself surrounded by articles of food in their most alluring and often least digestible forms, by sweetmeats, preserves, and cakes, and various special artifices for developing a tendency to dyspepsia; by wines, beers, and liqueurs, interspersed, it is true, with non-alcoholic beverages in almost endless variety, and flanked on one side by establishments offering gastronomic temptations equally to the thrifty and the extravagant, to the abstainers from meat and from alcohol, and the lovers of all that is comprised under the head of good cheer. A reference to his catalogue would inform him that food claimed by right the first place in an exhibition devoted to health, and he saw that this right had been most liberally

acknowledged; while the eager crowd, struggling at the door of the School of Cookery restaurant, demonstrated the truth of the statement which he would read in the next paragraph of his guide, that "it is still the struggle for food that occupies most of our thoughts and energies."

But even the most cursory general inspection of the Exhibition would soon show any intelligent observer that, while the Executive had sedulously fulfilled their instructions to interpret the relationship to health of objects offered for exposition in the most liberal manner possible, every department of the Exhibition was intimately connected with health, bodily and mental, and was replete with instruction and interest to the masses, and even to the most educated.

The Executive Council devoted much anxious consideration to the means to be adopted for giving point and prominence to the instructive aspects of every branch of the Exhibition, and with the invaluable aid of special subcommittees, composed of the most eminent authorities and practical workers in all relating to hygeine and to education, they succeeded in combining proper classification with systematic illustration and practical demonstration, and in eliminating, as far as was practicable, all objects which were either outside the scope of the Exhibition, or had no right to positions of prominence to which they have been exalted by those devices for impressing the public which are furnished in such profusion of variety from the resources of what may now almost be termed the science of advertisement. Even such special displays which constituted very prominent features in the Exhibition, as the historical collection of costumes, and the faithful reproduction of Old London shops and dwellings, contributed their quota to the instruction of those desiring to be informed; the former, by affording the means for comparison which are essential to the appreciation of what is good, and the condemnation of what is bad, in dress and fashion, from hygienic and æsthetic points of view; the latter, by leading us to see with our own eyes where we have been advancing, and where we have, to our shame, almost remained stationary in the construction and arrangement of our dwellings, and by furnishing to multitudes opportunities never before presented or embraced, of witnessing the working of trades germane to the objects of the Exhibition.

There is no need to point out the very instructive nature of several special exhibits, such as the two examples side by side of types of sanitary and insanitary houses, and the Metropolitan Water Companies' Exhibition; but this allusion to them leads me to refer to other special means which the Executive Council resorted to, in imitation of the course adopted at last year's Fisheries Exhibition, for rendering the resources of the exhibition fruitful of instruction. Its existence was made an opportunity for encouraging the public interchange of knowledge and views, by specialists and others actively interested in subjects dealt with in the Exhibition, and by the many who are in a position to bring the practical experience of daily life, or special experiences of a favourable or a more or less disastrous nature, to bear in confirmation or correction of views entertained by those whom we look to as authorities and counsellors in matters relating to the comprehensive subject of health.

The proceedings at the public conferences held at the Exhibition under the auspices of many different societies and associations, were, in the majority of instances, very interesting and instructive; and their publication, in conjunction with a series of valuable little handbooks on prominent subjects relating to public health and education, constitutes one of the most important contributions to the instructive literature of the day, especially as they are supplemented by reports of the many valuable lectures upon cognate subjects which were delivered to the visitors.

In relation to the subjects of dwellings for the poor and the higher class, and of the sanitary considerations connected therewith, and with the well-being of large and small communities, much important information was contained in the papers read, and elicited by the discussion thereon, at the Conferences held by the Medical Officers of Health in co-operation with two of the most important Sanitary Associations, by the Mansion House Council on the Dwellings of the Poor, by the Institution of British Architects, and by the Social Science Association. An intelligent listener from the outside public at some of these conferences must have afterwards proceeded with opened eyes to the examination of the model sanitary house in its several details—the dry and well-drained basement, the efficiently-lighted, warmed, and ventilated offices and dwelling-rooms, the airy bedrooms, the harmless and effective wall-coverings, paints, and decorations, the efficient, smokeless, cleanly and economical heating and culinary arrangements, and, above all, the

provisions for securing the water supply from all chance of contamination, and the cleansing and special sanitary arrangements, simple and permanently reliable in construction and operation, insuring the rapid and thorough removal of all that should pass away from a dwelling, and immunity from possible contamination of the air in the house.

The more or less glaringly insanitary details of fittings and arrangements in the companion house, though they may, let us hope, never before have been all contained within one single dwelling, could not fail to remind a large proportion of the visitors that one or other of those possible sources of disease or languishing health existed in their own habitations, and served admirably to bring out, by contrast, the good features of modern house fittings and arrangements, devised and constructed on sound principles, which were exemplified by the type of "a dwelling house as it should be." The eminent sanitary authorities and architects who executed these model houses were careful to point out, on the one hand, that the fittings used in the typical sanitary dwelling were by no means to be considered as standing alone in their comparative efficiency, a fact readily substantiated by a study of this department of the Exhibition, and affording highly satisfactory proof of the progress which has in recent times been made in the sound and skilful application of scientific principles in this direction. On the other hand, visitors to the insanitary house were warned not to conclude that their own dwellings were faultless from a sanitary point of view, if they contained none of the faulty fittings or defective arrangements shown. It was intended that each individual item in the typical example of defective sanitation should indicate a direction in which very serious errors have been, and, it is to be feared, are still but too frequently, committed by those whom we should expect to be competent to fulfil their responsibilities as the architects of our dwellings. In this way the insanitary dwelling has certainly produced salutary results. The comparatively new profession of sanitary engineer cannot fail to exercise a most beneficial influence over some of the most important work of the architect; indeed, most valuable reforms have already been introduced into the details of arrangement of dwellings, for the poorer perhaps even more than the wealthier classes; but it is in dealing with the sanitary improvement of existing buildings that the services of the sanitary engineer are especially needed in grappling with the formidable difficulties which have to be encountered, and that the beneficial influence of our recent Exhibition and its Conferences have to be demonstrated. The system of sanitary examination of houses, recently organised by private societies, has already been productive of great good, by bringing to the knowledge of the occupant of a house the true state of things in regard to its insanitary condition, and by indicating the directions in which improvement is possible. It is a question whether, without overstraining the application of paternal legislation, by which, in the opinion of many, we have of late been somewhat oppressed, official local supervision in regard to sanitary matters may not beneficially be further amplified, even though, or for the very reason that, the last few years have witnessed advances in this direction which have been fruitful of very important results. The solid knowledge which has been acquired of the causes to which the spread of many diseases is to be ascribed, has been reflected in the improvements relating to domestic sanitary arrangements which the recent Exhibition brought prominently before the public, but although the public mind has been awakened to the vital importance of the practical fulfilment of fundamental sanitary principles, its realisation is scarcely yet so general and complete as to ensure the adoption of reforms which will warrant our communities facing, without very formidable cause for fear, or for tardy regret at obstinate supineness, the approach of such diseases as that which even now appears to threaten the invasion of our shores.

The direct beneficial influence which competitive Exhibitions may exert in developing progress in directions where improvement has long been almost despaired of, is illustrated by the effect of the recent Smoke Abatement Exhibition in arousing general public attention to the semi-barbarous nature of appliances in common use which make the heating of dwellings and cooking of food subservient to an almost criminal waste of coal, and in stimulating the efforts of constructors of stoves, grates, and ranges to more successful achievements than even those which were hailed with most general satisfaction in 1881. I am informed by Dr. Russell, the chairman of the jury who have investigated the relative merits of exhibits of this class in the late Exhibition, that there was no single instance in which the results furnished by the corresponding examination of the work of a particular maker in 1881 could be accepted as

representing the merits of his exhibit on this occasion; efforts having in every instance been made to achieve an advance, either in the extent to which the escape of smoke and the wasteful consumption of fuel were avoided, and ventilation secured, in the warming of a room, or in simplicity of construction or management of an already efficient stove, grate, or range.

Without even necessarily endorsing statements which may, perhaps, have partaken of some pardonable exaggeration, respecting the proportion of wasted coal escaping into the air as smoke, or as products of imperfect combustion, or respecting the extent to which the sanitary condition of large communities may have been, directly or indirectly, affected by the pollution of the air with the products of distillation and partial combustion of coal which escape from our dwellings, we may, at least from economic and æsthetic points of view, hail with great satisfaction the improvements which have already resulted from public agitation, and from the judicious counsel and example of zealous workers, combining scientific eminence with practical knowledge and ripe experience, among whom, again, Sir William Siemens was one of the most prominent.

It may be doubted whether the youngest among us will live to see the complete realisation of the benefits to be derived from the mode of using coal as fuel which was so powerfully advocated, with the support of sound scientific reasoning and personal experience, by Siemens. At any rate, some of the chief industries of this country have benefited enormously by the teachings in this direction of himself and his brother Frederick, who is still perfecting and extending the applications of the regenerative furnace, working with gaseous fuel only; while, on the other hand, the plan of securing warmth and perfect comfort in the dwelling-room, by combining the use of the previously separated solid and gaseous constituents of coal, in a very simple manner in the ordinary fire-place, has added one more to the many valuable suggestions we owe to Sir William Siemens, which have set practical workers upon the right track, and have greatly accelerated the advancement of the subject to which they relate.

It is many years since attention was first directed to advantages indicated by theory, and which appeared practically realisable, from the application of certain liquid hydrocarbons as fuel for engine purposes; and before even chemists dreamt of the possible future value of coal tar as a source of brilliant dyes, attempts were made to apply crude coal-tar naphtha as fuel for boilers. Later on, crude petroleum, and the heavier and less readily inflammable liquid hydrocarbons remaining after extraction, from coal tar and petroleum, of the portions available for colour-producing and illuminating purposes, have been applied experimentally in this direction from time to time, and with some success, the liquid being injected into the fireplace in the form of a spray, by means of ordinary or super-heated steam. A successful experiment has quite recently been made at the Forth Bridge Works, in working the furnace of one of the air-compressing engines with the residual product of the distillation of shale oil, obtained at one of the largest Scotch mineral oil works. This butter-like material, liquefiable by heat, for which no use has been found, even for coarse lubricating purposes, and which cannot be ignited by the application of flame in the ordinary way, is allowed to flow through a superheating apparatus, and is thence carried into the furnace by a powerful jet of super-heated steam; the force of the jet draws a powerful current of air into the centre of the flame produced by burning the mixture of vapours and of minutely divided liquid, and the result is said to be an almost perfect combustion of the fuel with total absence of smoke and of solid residue in the furnace. Even at the locality of this experiment, where coal is cheap, it is claimed that an ultimate economy will be effected by the use of this fuel, the cost of labour for stoking being much diminished. This experiment has been valuable as showing that the residual products of British mineral oil works may be utilised with advantage as substitutes for coal; but far more important results have been obtained in this direction in Southern Russia during the last few years. The value of the residual product of petroleum distillation, as an efficient and economical source of steam power, has been conclusively established in connection with the marvellous development, by the Brothers Nobel, of the petroleum industry at the Baku Works, which are fed through pipe-lines of an aggregate length of over sixty miles, by the apparently inexhaustible supplies of petroleum of the Aspheron Peninsula. The residual or heavy oil, which remains after extraction of the illuminating and lubricating oils from the petroleum, and of which Messrs. Nobel alone produce now 450,000 tons annually, is already

used as fuel on upwards of 300 steamers upon the Caspian Sea and the Volga, and by the locomotives on the Trans-Caucasian and Trans-Caspian railways. Its use is also extending to other railways in South-East Russia and to manufactories in Moscow, where it is rapidly replacing English coal. In an instructive paper on the employment of refuse petroleum as fuel in locomotive engines, recently communicated to the Institution of Mechanical Engineers, Mr. Urquhart has shown that, weight for weight, it has 33 per cent. higher evaporative value than anthracite, and that while 60 per cent. of efficiency is realised with the latter, 75 per cent. is obtained with petroleum refuse. The spray injectors, which maintain a uniform supply of liquid fuel to the boiler-fires, are very efficiently worked, so as to ensure complete combustion and consequent absence of smoke; the supply of fuel by conduits to different stations from a main reservoir, and the feeding of the locomotives with fuel supplies, along a line of 300 miles, are very simply and efficientlyarranged. The smaller proportion of liquid fuel required and the relatively small bulk which it occupies as compared to coal, lead to an economy of space which is especially valuable in steamers. The liquid, conveyed in closed tanks, is expelled from these to the furnaces by pumping in water, so that the ballast of the vessel is not materially affected by the consumption of fuel, and the saving in stoking labour in a ship is very considerable. The Russian Government have for some years past had several of the gunboats of the Caspian fleet worked with this liquid fuel, and are so satisfied with the results that they are contemplating its use for the Black Sea fleet. The very rapidly continuous extension of the Russian petroleum industry appears to assure a most important future to liquid fuel, and though it is hardly likely to compete in this country with coal for locomotive purposes generally, the comparative ease with which its perfect combustion is now insured, appears to render it especially suitable for employment in underground railways, while its use in steamers cannot fail to be attended with important advantage in many special services.

To revert briefly to the conferences held at the Health Exhibition, I would refer to two which have dealt with subjects of immediate and vital importance to health; one being the existing means and measures for guarding against the supply of adulterated articles of food and drink, the other, the frequently discussed, but not yet thoroughly thrashed out, question of water supply to large and small communities.

The Institute of Chemistry did good service, in which the Society of Public Analysts importantly assisted, in bringing together professional chemists, and more especially those who hold the highly important and responsible positions of public analysts, to discuss among themselves the extent to which the existing legislation for preventing adulteration of food has proved satisfactory in its working and results, the directions in which it needed modification or extension, and the important questions of the causes of occasional differences in conclusions arrived at by different analysts on such subjects as the nature and extent of adulterations in important articles of food. Dr. Bell, the chief of the Inland Revenue Laboratory, in submitting to the conference a very able address, for the purpose of initiating discussion, showed that, from the time when first the attention of Parliament was directed, in 1855, to the serious systematic adulteration of foods, drinks, and drugs which then prevailed, improvements in the condition of things became manifest; but that a most important advance was made upon the beneficial effects of previous legislation by the passing of the Sale of Food and Drugs Act, in 1875, which led to the appointment of public analysts throughout the country, and by the subsequent Act of 1879. In 1880, there were 17,763 samples of food and drink analysed in England and Wales, of which 15.7 per cent. were reported adulterated; and in 1882, the number of analyses was 19,439, the reported adulterations amounting to 15 per cent. In Scotland, but very little use indeed has been made of the power to check adulterations which the existing Acts provide; but in Ireland, only one borough and one county exist in which public analysts are not appointed. In England, there are still districts in which the Acts are practically a dead letter, even in some cases where they are nominally complied with. The natural re-reluctance of private individuals to incur even the expense of the analyst's very moderate fee, and the trouble involved in the event of a prosecution, especially with the working-classes, who are the greatest sufferers from adulteration, the frequently abortive course taken by local officials in the collection of proper samples, in cases where the practice of adulteration is suspected, added to the smallness of the fines often imposed by magistrates in cases of conviction, are causes which have

combined to limit or retard the beneficial operation of the Acts. Nevertheless, the resulting benefits have been most important; at any rate, the more deleterious forms of adulteration, so largely practised when first this subject attracted serious attention, have long ceased to exist; while the control exercised in all larger towns by the analyst over the purity of the most important articles of food susceptible of sophistication, where the temptation to the practice of adulteration was enhanced by sharp competition, has become very effective, if not complete. It is, indeed, a subject for congratulation that so much has been accomplished. Those who have at heart the subject of the promotion of public health, and the protection of the poorer classes against a system of deception most detrimental to their well-being, should at the same time appreciate the difficulties which have had to be surmounted, in order to deal, as definitely as is necessary for the satisfaction of legal requirements, with the practices of adulteration, and with such points as the limitations to be fixed for admissible variations in the components of some descriptions of food, the ordinary adulterants of which are of the same nature as some of the proper constituent parts of the article of food, and the allowances which have to be made for accidental but natural fluctuations in the quality or composition of a particular kind of food.

One of the many difficulties which beset the subject of control over the purity of important articles of food exists in the fact that purity may be so distinct from wholesomeness that, for example, an article of superior quality, when mixed with a considerable proportion of a perfectly wholesome and, perhaps, equally nutritive adulterant, may be a more wholesome food than a perfectly genuine but inferior quality of the same article. The fact that an adulterant is not of necessity deleterious, and is only prohibitable if used for purposes of increasing the profit upon an article of food, or of surreptitiously improving inferior qualities of food, is legally recognised, it being perfectly lawful to sell, under its correct denomination, a particular food largely composed of a substance the surreptitious employment of which, even in much smaller proportion, would be condemned as an act of adulteration. The legalised employment of chicory in admixture with coffee, the mixture being specifically sold as such, illustrates this point. A mixture of butter and lard may be legitimately offered for sale, if so described, but if sold as butter it would be condemned as an adulterated food. The circumstance that the softer portion of sweet fat, known as oleomargarine, when worked up with certain vegetable oils to a perfectly palatable and nutritious mixture, of butter-like consistency, is sold under the name of "butterine," has brought upon this useful preparation unmerited condemnation, because the temptation is strong either to allow the article to lose its identity by union with butter, or to dispense with the insignificant terminal syllable by which it is identified, and to offer the unadulterated butterine as butter. Its sale as an adulterant, or as butter, is clearly illegal; but it is to be deplored that, on this account, a wholesome article of food, the preparation of which from materials of unquestionable quality is as readily controlled by proper inspection as the production of other articles of wholesome food, should be condemned in the public press as a vile compound, and stigmatised as being prepared simply for purposes of deception.

The difficulties which the analyst has had to encounter, in deciding upon methods of examination which shall furnish results not susceptible of dispute, in determining upon the limits in regard to quantity within which certaln substances liable to be used for purposes of adulteration, or cheapening, but which are also normal components of certain foods and drinks, shall be considered admissible or legitimate, and in many other matters connected with his work, have been very formidable, and it is not surprising that cases should have occasionally arisen in which hardship has been inflicted upon the salesman, or in which the guilty have escaped punishment, consequent upon the conflicting nature of results arrived at by different analysts in defended cases, or in cases of appeal to the official referees. The Society of Public Analysts has done most useful work in leading to uniformity in methods of examination, and to the clearing up of difficulties which had been fruitful sources of dispute, and such conferences as the one recently held cannot fail to conduce to further uniformity of action, besides being of benefit to the public, in bringing to the knowledge of the authorities the weak points in the working of existing legislation, concerning which there is a consensus of opinion among those who best know how the law now operates, and the direction in which it needs modification, or could be extended with benefit.

In holding the Conference on Water Supply at the Health Exhibition, the Society of Arts,

at the express desire of its President, continued the useful work which it had undertaken on two previous occasions, of eliciting information and opinions bearing upon the condition of the water supply in this and other towns, and the directions in which improvements could be effected, not only therein, but also in supplies to smaller communities and urban districts. The valuable papers communicated to the Conference, as the basis for discussion, dealt more or less generally with sources of supply, with purification and distribution; but, although the question of the water supply of the metropolis had been but recently discussed at great length in this room, by eminent specialists and others who have for years past made it a subject of keen controversy, and a battlefield for the display of extreme views and sensational statistics, arguments, and assumptions, the discussions which followed those papers gravitated irresistibly in the same direction, and the important subject of the possible improvement of the water supply to urban districts, which has long called for earnest attention, was again neglected. Certain advocates for the abandonment of river water as our metropolitan source of supply, in exclusive favour of deep well water, once more dwelt with a refinement of cruelty upon the insidious dangers to which, from their point of view, we are continuously and helplessly exposed under our existing system of supply, and extolled the deep well as a source from which the enormous population of London could draw limitless supplies of the purest water, to which no microscopic contamination could have access. On the other hand, the general wholesomeness of our present supplies was held, and apparently with much justice, to be beyond legitimate dispute, when judged by any chemical examination to which, with our present knowledge, we could submit a water; but the undeniably possible sources of danger, from occasional contamination by impurities the identification of which is beyond the powers of analysis, were discarded from serious consideration. The intimate connection between the existence and communication of particular classes of disease and the presence and propagation of minute living organisims, as also the facility with which a living being may become inoculated thereby through the medium of air and water, have long since been well-established facts, though from year to year new and invaluable information respecting the relation of germs to disease is accumulated. The exclusion from access to water which is to be used as drink, of emanations which are liable to convey the germs of infectious disease, is obviously a precautionary measure which all would desire to see secured as far as possible, even those who entertain the strongest views regarding the powers of self-purification from contamination of this class possessed by a flowing water. Unfortunately, our powers to effect such exclusion are very limited. Thus, even brief contact with infected air of a water the purity of which has been placed beyond question by its special treatment, suffices to pollute it far more dangerously than its admixture with a proportion of so-called healthy sewage. But this is no reason why we should not adopt every practicable precaution to exclude such sources of possible infection from our water-supplies as it is practicable to grapple with. It is not unreasonable to entertain the view that rivers or streams to which excretal emanations unavoidably have access should be liable, at times, to dangerous pollution of this kind, and that it may be unsafe to rely upon the purifying power of dissolved oxygen in the water, even during a long period of flow, as removing all risk of a survival of such dangerous contamination. But, again, unhappily, recourse to deep wells in substitution for rivers as the source of water-supply does not remove, though perhaps it may somewhat diminish, the danger to which we are exposed. Our limited recourse to deep wells has taught us that even their most careful construction does not afford security against more or less copious and continuous contamination by surface water; and independently of faults and fissures in the water-bearing strata, the communications existing between distant wells, and the influence of the working of deep wells upon the copiousness of neighbouring streams and rivers, has long been well known, as pointed out by Sir Lyon Playfair in this room last session. This was forcibly dwelt upon by several speakers during the recent conference, more especially by Mr. Baldwin Latham, who, moreover, referred to personal observation and investigation as establishing, in a particular district which received underground water supply, a parallelism between the condition of that water and the recurrence of typhoid fever in the district. An interesting illustration of the intimate connection between the water supply of different wells situated at some distance from each other, has quite recently been furnished by the

complete failure in the supplies from a large number of artesian wells in the neighbourhood of Tooting, in consequence of the sinking of a deep well at Streatham, about a mile distant from that place, by the Lambeth and Vauxhall Water Company.

It is maintained by some that the filtration of water through strata of compact chalk and sand should constitute the most perfect attainable purifying agency, but, independently of the fact that a large proportion must escape such purification more or less completely by passing through fissures, evidence is not wanting to render it doubtful whether such extremely minute organisms as bacilli and other forms of bacteria can be absolutely arrested by the most perfect filtration alone. Thus, in a district in the United States, where the infusorial silicious earth, known as kieselguhr, is employed for manurial purposes, some of the larger forms of diatomaceæ existing in that earth, which are giants as compared to the micro-organisms we so greatly dread, have been found abundantly within the cell-structure of plants grown on the soil.

On the other hand, there appears some reason for believing that these micro-organisms are not unassailable, chemically, by agents which at first sight we might regard as innocuous, however indifferent such organisms, in common with others of a much more higher order, may be to substances which are deadly poisons to the animal creation generally; and I venture to think that our hope for a radical improvement in the water supply of this great metropolis, lies rather in the application of some simple, expeditious, cheap and effective mode of chemical treatment to supplies from sources now in use, previous to their filtration, than in a complete change of our source of supply.

The importance of combining microscopical with the chemical examination of a water, and of a combination of other chemical tests with mere analysis, if some approach to an authoritative opinion as to its wholesomeness is to be given, need scarcely be insisted upon. From this point of view, the simple outline regarding the examination of water included in the Exhibition Handbook on "Public Health Laboratory Work" is much to be commended, and hereby I am reminded that my reference to the useful work accomplished by that part of the Exhibition which related to bodily health would, indeed, be blameably incomplete were I to omit special allusion to the debt of gratitude the public owe to the Laboratory Sub-Committee of the Exhibition Executive, for having conceived and so admirably carried into effect the establishment of public laboratories in connection with the Exhibition, where the direct applications of chemical and microscopic research to the protection of health could be exhibited, and made generally intelligible to visitors of average ability.

In the hygienic laboratory, under the superintendence of Professor Corfield, who directed its installation, excellent lectures and practical demonstrations were given by Mr. Charles Cassal of the most approved methods of examining air, water, and certain foods and drinks, for purity and quality, as also of certain special methods of detecting deleterious substances in paints, paper-hangings, clothing, &c. The details of arrangement and fitting of the laboratory were excellently adapted to the special descriptions of chemical work which falls to the duty of health officers and public analysts, and cannot fail to have been much visited, and with personal advantage, by officials of that class. The biological laboratory, arranged and conducted under the superintendence of Mr. Watson Cheyne, the talented disciple of Lister and Koch, together with the unique display contributed to the Exhibition by M. Pasteur, of the apparatus and instruments with which he has achieved some of his greatest triumphs of biological and pathogenitic research, afforded not only the public generally, but also a large proportion of the British scientific world, the first opportunity of becoming practically acquainted with the methods of carrying on a class of research which has, until lately, been chiefly pursued in Germany and France. The identification of the different varieties of micro-organisms, which, in some cases, have been conclusively proved to be the causes of communication of infectious and contagious diseases; the study of their characteristic properties or habits, and of the conditions favourable to their growth and propagation, or antagonistic to their existence; the inquiry into the conditions to be fulfilled for eliminating sources of contamination from vaccine lymph, and for cultivating the pure germ; the investigation of the nature of ferments, moulds, rusts, and mildews—these are some illustrations of the very special and important work pursued in such a laboratory as that presided over by Mr. Cheyne, who, with his assistant, Mr. Cassal, devoted himself enthusiastically to the instruction of those desiring to embrace the opportunity of obtaining an insight into this important branch of

research. In France and Germany, laboratories of the kind illustrated by these model laboratories were some time since established by official bodies for purposes of research, and the invaluable work already accomplished through their agency must assuredly be regarded as affording the strongest reason for a favourable entertainment of the suggestion, made by the late Laboratory Sub-Committee of the Exhibition, that steps should be taken to place these laboratories or their counterparts upon a permanent footing, and to develop from that germ a Public Health Institute or College of a really national character.

The instruction which has been afforded to the public by these laboratories of the Exhibition leads me to remind you, in a few concluding words, of the very prominent position which the subjects of general education and of bodily training occupied in this Health Exhibition. By no means the least interesting of its features were exhibits and practical demonstrations illustrating the different systems of systematic exercise and drill in use here and abroad ; and the beneficial effects of physical education upon the bodily health, physique, and discipline of the young, could have received no more satisfactory illustration than was afforded by the annual school review and competition in drill of Board schools, held by the School Board of London in connection with the Exhibition, last July. Those among us who on that occasion could recall to mind the first drill competition organised by the Society of Arts, in June, 1870, could not but be much impressed with the great advance which has been made since then in physical training at schools, a result which must have been specially gratifying to the originator of these school reviews, the early and ardent advocate of this indispensable element in the proper training of the young, our veteran colleague, Mr. Chadwick, to whom this Society and the country generally owe so much for his unceasing labours in the interests of public health and national education.

The publication of the complete proceedings of the International Conference on Education, which was organised by a special sub-committee, and was so successfully directed by Lord Reay, is looked forward to with much interest on account of the valuable nature of the communications brought before the meetings and of the discussions by which they were followed, in which not only our chief authorities on educational matters, but also many foreigners of eminence in different departments of education, took part. The subjects of elementary education (which may have been said to have celebrated its 50th jubilee on this occasion), and of the processes by which its progress and improvement might be promoted, naturally received a large share of attention, though scarcely less interest attaches to the papers and discussions bearing on the questions of secondary education, and of the measures which it might be hoped that the responsible State authority on education, would adopt for giving organisation to and raising the present standard of secondary education. The organisation of university training, and the possibility of throwing open the English university education to the most promising student from among the masses of the population, were among the prominent topics dealt with, while the subject of technical education and of the conditions which would have to be met in attempting to organise a national system of technical training, received the attention to which its importance entitled it. The subject of the prevalence of overpressure in elementary schools, to which public attention has been much directed of late, was dealt with by a special conference organised by the London Medical Association. The relative merits of different methods of physical training in schools for boys and girls was also discussed at the Educational Conference, and several other interesting topics were dealt with, which had a direct bearing upon the educational section of the Exhibition. This section, which was housed in part in the Albert-hall and in the new Central Institution, or College of Technical Education, constituted in itself an Exhibition of a most comprehensive and interesting nature, especially instructive by the opportunities it afforded for a comparison between different methods pursued, and the results they furnish, in elementary, advanced, and technical schools in this country, and in France and Belgium, and by the ample illustration of the progress made in the arrangement, furniture, and appliances for schools, and of the good work accomplished by the créches and kindergarten systems.

At this late hour I dare not venture upon more than an allusion to the benefits already accruing from the great movement which was set on foot only a very few years ago in this country, in favour of technical education. The valuable labours of the Royal Commission on technical instruction, and the good influence exercised by their investigations of the condition of things at home and of the results

achieved in other countries, have not only served to give a new impetus and new directions to the work, already pursued at existing centres of instruction, but have led to, or much accelerated, the establishment of important educational institutions, which have for their objects the teaching of science in its applications to pursuits of all classes—to trades, manufactures, agriculture, and the Arts; and the simultaneous development of practical skill and of that sound acquaintance with the scientific principles which, quite equally with skill, lies at the root of success and progress.

The Society of Arts may justly be proud of the position it has frequently occupied as the initiator of movements and undertakings which have afterwards developed into national importance, but there is no original work upon which it has greater cause to look back with satisfaction than that organisation of examinations, held simultaneously at centres in different parts of the country, which became the foundation of the more comprehensive system now for many years pursued by the Science and Art Department; and that initiation of examinations in several branches of technology which it first undertook eleven years ago, at the suggestion of Colonel Donnelly. Those examinations had already been attended by most decided success, when, five years later, the work was taken up by the then newly founded Corporation, which has already made its usefulness felt throughout this country —the City and Guilds of London Institute for the Advancement of Technical Education. The success with which the resources of this institute, the wise deliberations of its executive, and the energy and power of organisation of its talented director, have been applied to the extension and satisfactory working of these examinations, is demonstrated by the fact that, while the total number of candidates who presented themselves in the first year (1879) after this work was taken over from the Society of Arts, was 202 (having risen from 6 to that number in 7 years), the number of candidates this year has been 3,635, while the number of centres at which examinations have been held have increased from 23 (in 1879) to 164. During the first three years that these technological examinations were held by the Society of Acts, the subjects dealt with, representing different industries and trades, were increased from 5 to 13; they now amount to 34, of which 6 include several distinct branches. The statistics furnished by the results of these examinations are very valuable, as indicating the direction in which the instruction of the candidates may with great advantage be modified or increased in efficiency; indeed, it appears from them that while the successful organisation of these examinations has led to the establishment of classes of instruction, supplementary to the general science teaching in every large manufacturing centre, and to the generally good attendance at those classes, the increase in the number of candidates examined has been accompanied by an increase in the per-centage of failures to pass the examinations; and that any important improvement in technical education, at distances from great centres of instruction, now hinges upon the supply of a serious existing deficiency in competent teachers. It is in this direction that the sphere of usefulness of the City and Guilds Institute promises to be extended with special benefit.

The work of the Institute, up to the present time has, as you are aware, been by no means confined to the successful devolopment of the benefits accruing from well-organised, intelligently and legitimately conducted, examinations in technological subjects. Important money grants have materially promoted and widened the scope and powers of existing institutions, where instruction in applied science, and training in technical operations, are pursued. The development of the South London School of Technical Art has already been fruitful of important results, and the establishment of the Finsbury Technical College has supplied the metropolis with a school especially adapted to meet the requirements of the apprentice, the artisan, and other subordinate workers in many important callings, already vying, as regards completeness and efficiency, with the best Continental schools of this class. That this institution has met an existing want is demonstrated by the fact that although the new building was only opened early last year, the number attending during the year were 799, of whom 699 attended the evening classes in physics and electrical engineering, in chemistry, in mechanical engineering, in art, and in subjects specially relating to certain trades.

Competent critics who have closely inspected the working of the college in its details, have been unanimous in their testimony that the methods of teaching which have been introduced by the several instructors, and which, in some instances, exhibit an important departure from what may be termed traditional systems, are in general most admirably calcu-

lated to instil sound knowledge of the principles of science and of art, and to demonstrate their true relations and importance to the several trades or manufactures in which the students are individually interested.

The public has already become familiar with the magnificent building known as the Central Institution, which is destined to become the university of technology in this country. Its inauguration last summer was most happily combined with the display, within its walls, of the instructive educational exhibition to which I have referred, and with the first public demonstration in England of the achievements of experimental science in relation to public health.

The carefully considered scheme for the organisation of this Central Institution is now upon the eve of being carried into effect, and the preliminary programme, which was issued some months since, well illustrates the special functions which this new college may be expected to fulfil. The work of preliminary training in science, and of special education, of those who desire to devote themselves to pure science, to a professional career, or to the duties of the important class of instructors in schools known as science teachers, will be, as far as possible, left untouched in the hands of the Royal Schools of Science and of other establishments connected with our universities. The technical college, seeking for its students among those who have become sufficiently qualified by preliminary scientific training, will aim at providing special instruction, and facilities for acquiring practical knowledge, for those who desire to devote themselves to some industrial career, to become managers or experts at manufacturing establishments, or instructors in the applied sciences, or to embrace a profession in which the attainment of proficiency involves an intimate acquaintance with the practical bearings of the sciences in that direction. The scheme of the central institution also includes the provision of special laboratories, where researches connected with technical chemistry can be carried out by advanced students, and the delivery, from time to time, of lectures distinct from the ordinary courses, by eminent specialists in particular branches of technology.

That the work done by the new college should, in some small degree, trench upon that hitherto performed by existing schools, is perhaps unavoidable, especially in the matter of comparatively elementary training in particular directions, which may prove necessary with one or other class of students; but it is the distinct aim of the Central Institution of Technology to be mainly special in its character, and to meet the acknowledged deficiency of the educational resources of this country in facilities for pursuing the study of science in most of its direct applications to trades and industries. The high scientific position and special qualifications of the four gentlemen who have been appointed to fill the post of principal Professors, afford a guarantee that the new work which the City and Guilds Institute is entering upon has ensured to it that important factor of success which must spring from a combination, in those who direct the studies of the highest abilities with earnest devotion to the work of teaching, and power to kindle and foster a love of work in the pupil. It is noteworthy that two of the Professors have been chosen from among the most successful of those who initiated the work so satisfactorily progressing at the Finsbury College, and who have thereby acquired special experience which cannot fail to be of the highest value in the elaboration of the system of teaching to be pursued at the central institution. It may be confidently expected that the elder offspring of the City and Guilds Institute will afford most valuable support to the younger, by supplying it, from year to year, with a large proportion of its most thoroughly qualified pupils, whose success at the Central Institution will reflect lustre equally on these two important establishments, bound together by common interests, and working harmoniously for one common object, the advancement of our national prosperity.

I cannot conclude this address withont a word of reference to the approaching International Exhibition of Inventions, the prosaically utilitarian character of which is to be tempered by its association with all that is most interesting in the history and the later development of music. Arguments and facts have been adduced to support the view that an Exhibition of Inventions, organised upon the principles laid down by the Executive Council, if it is to be made at all representative of the results of successful invention, and really illustrative of the working of inventions relating to important industrial processes, is likely to be detrimental to the interests of our national industries. Into the discussion of such arguments I dare not now attempt to enter, but I will venture to predict that, although the very natural desire to preserve as personal property the results of expenditure of

ingenuity, labour, and capital, may deter many from publicly exhibiting the methods or appliances by which more or less important improvements in particular industries have been achieved, the character and results of the Exhibition will demonstrate that the principles which have governed its organisation have proved the reverse of detrimental, either to its importance, or to the interests of progress in the development of our trades and manufactures.

Your Council, in assisting to the utmost the executive authorities of these successive exhibitions in their very arduous gratuitous labors, have felt confident of the approval of the Society at large, it being in complete harmony with the traditions of the Society for the Encouragement of Arts, Manufactures, and Commerce that its governing body should take an active, and, if possible, a leading part in any movement calculated to promote the enlightenment, prosperity, and general well-being of her Majesty's subjects at home and abroad, and to foster and knit together more closely the bonds of sympathy and of mutual interest which unite us to other nations.

Sir Frederick Bramwell, F.R.S., said it devolved upon him, as the preceding occupant of the chair, to move a vote of thanks to Sir Frederick Abel, and he regretted exceedingly that this privilege should not have been exercised by him whose eulogy had been given in the early part of the address—the late Sir William Siemens. The address itself was of the most comprehensive character, dealing with a large number of subjects, and any attempt to review it would be only an impertinence. The Society, however, was to be heartily congratulated on having Sir Frederick Abel as its Chairman of Council; he (Sir Frederick Bramwell) had known him for the last quarter of a century in very many capacities; he was one of the most busy men he knew, but yet, as had been said of others, he always found time to do that which he was asked to do for a good object. He never knew him refrain from keeping an appointment or undertaking duties he was asked to perform, if he thought good would result. Having himself occupied the chair of the Council of that Society, he knew that it meant a good deal of hard work; but besides that, Sir Frederick Abel had consented to become a liveryman of the Goldsmiths' Company, in succession to Sir William Siemens, in order that he might be on the Executive Council of the City and Guilds Institute, whose work he had narrated. At every meeting of that Council he was present, and he was not merely a lay figure, for his views were always worthy of the deepest consideration. He had been a member of the Council of the Exhibition which had recently closed, and he was glad to say that he was also on the Council of the coming Exhibition; in fact, whether in the service of the Government directly, or in that of the nation at large indirectly, there was no opportunity for work offered him which he did not find time for. With regard to the approaching Exhibition, he (Sir Frederick Bramwell) being chairman of the executive, and feeling a deep personal interest in it, he might be allowed to say just a word. Sir Frederick Abel had alluded to the suggestions which had been made that such Exhibitions did harm by revealing secrets. That question was well thrashed out prior to the first Great Exhibition of 1851, and he thought the ghost which was then raised had been laid for ever. However, as it seemed to have been revived, he wished to point out one simple answer to the objection; he was in a position to state, and his colleague, Mr. Webster, could confirm him, that fully 85 per cent. of the applications for space were to exhibit inventions which were the subject of patents. Now when an invention was patented, one of two things occurred—either the inventor had truly stated in his specification the best means he knew of for carrying his invention into operation, or he had not, in which case his patent was invalid; he had, in fact, told an untruth in his specification. But if he had told the truth, as he was bound to do in honour and honesty, any person could without payment, by going to the Patent-office, read the whole of his specification and get the whole information, and by paying a few pence could take away a printed copy. Therefore there was no extra revelation made of any matter which was not the subject of a patent. These, as he had said, amounted to 85 per cent. of the applications; with reference to the remainder, it was required that they should be vouched for by persons of repute as being really matters of novelty and interest, introduced since the year 1862. It was, therefore, one of the most idle statements ever made to say that this Exhibition was one in which would be revealed that which could not be arrived at except by the Exhibition itself. He must not stay to touch on any of the other topics alluded to in the address, but he was quite sure all would agree with him in congratulating the Society on having a man of the capacity of Sir Frederick Abel to fill the chair, and in the estimate of what they owed him for this admirable address, which would form a text-book of the progress made during the last few years.

Lord Alfred Churchill, in seconding the vote of thanks, said all the members must feel themselves exceptionately fortunate in having secured the services of Sir Frederick Abel, as Chairman of Council, for the ensuing year. It would be impossible to find anyone more thoroughly capable in every way of conducting the proceedings of the Society; he was familiar with its various operations, and especially

with the growth of the Technical College of the City and Guilds Institute, which arose out of the action of the Society, promoted by Colonel Donnelly, some few years ago, in introducing a series of examinations in technological subjects. The essential object of the Society was to take the lead in every useful measure calculated to benefit mankind; and this had been shown, not only with regard to the question of technical education, but in other instances as well. The Royal College of Music arose out of the action of the Society in founding, under the able direction of Sir Henry Cole, a National Training School for Music; and other movements of great benefit to society at large had resulted, in a similar way, from action originally taken by the Society of Arts. He begged leave, most cordially to second the vote of thanks.

The motion having been carried unanimously,

Sir FREDERICK ABEL, in response, said the kind expressions which the mover and seconder had indulged in, with regard to his endeavours to be of use to the Society, had quite overcome him; he could only say that he felt extremely the honour which the Society and Council had done him, he felt deeply the responsibilities which his position entailed, and would endeavour to the utmost to discharge them.

The Chairman then presented the following Medals:—

The Society's Gold Medal for exhibits in the International Health Exhibition:—

John Stock Prize, for the best example of sanitary architectural construction, Classes 20, 28, 29, 30, 32, to Messrs. Doulton.

Shaw Trust, for the most deserving exhibit in Classes 41, 42, 43, and 45, to the Compressed Lime Cartridge Company.

North London Exhibition Trust, for the best set of specimens illustrating the handicraft teaching in any school, Classes 49 and 50, to M. Germain, on account of the Collective Exhibit from Belgian Normal Schools for Women Teachers.

Fothergill Trust, for the best exhibit in Class 26 (Lighting Apparatus), to Messrs. Nobel Brothers.

Trevelyan Prize Fund, for the best exhibit in each of the following Classes—2, 3, 5, 7, and 11 (all comprised within Group 1. "Food"), to the San José Fruit Company (in Class 2); to Messrs. Moir and Company (in Class 3); to Mrs. Charles Clarke, of the School of Cookery (in Class 6); to M. Pasteur (in Class 7); to Messrs. J. and E. Hall (in Class 11).

The Siemens' Prize, offered through the Council by Lady Siemens, for the best application of gas to heating and cooking in dwellings, Class 25, to Thomas Fletcher.

The Stacy Prize, offered through the Council by Mr. J. Sargeant Stacy, for the best exhibit in Class 30 (objects for Internal Decoration and Use in the Dwelling; Fittings and Furniture), to Messrs. Collinson and Lock.

The Society's Silver Medal for papers read before the Society during the last Session:—

To THE MOST HON. THE MARQUIS OF LORNE, K.T., for his paper on "Canada and its Products."

To REV. J. A. RIVINGTON, for his paper on a "New Process of Permanent Mural Painting, invented by Adolf Keim."

To C. V. BOYS, for his paper on "Bicycles and Tricycles."

To PROFESSOR FLEEMING JENKIN, F.R.S., for his paper on "Telpherage."

To I. PROBERT, for his paper on "Primary Batteries for Electric Lighting."

To H. H. JOHNSTON, for his paper on "The Portuguese Colonies of West Africa."

To PROFESSOR SILVANUS P. THOMPSON, for his paper on "Recent Progress in Dynamo-Electric Machinery."

To EDWARD C. STANFORD, F.C.S., for his paper on "Economic Applications of Seaweed."

To W. SETON-KARR, for his paper on "The New Bengal Rent Bill."

To C. PURDON CLARKE, C.I.E., for his paper on "Street Architecture in India."

Miscellaneous.

THE ANTWERP INTERNATIONAL EXHIBITION, 1885.

The Commercial, Industrial, and Maritime Association of Antwerp purposes to erect a monumental group, illustrative of the national and international commerce since 1830. The pyramid will be 100 metres square at the base, and 15 metres high. On the basement, in marble 7 feet high, with pedestals, will represent the sixteen principal ports of Europe and the world. The front face will have a plan of Antwerp, with views of the port in 1500 and 1885; and the Suez and Panama canals. It will also be ornamented with the arms of Antwerp and Belgium. Above this will be representative groups of objects forming the commerce of Belgium with different countries, in decennial proportions, indicated by different banners, during the last 55 years, and surmounted by the flags of all nations, emblematical of commercial fraternity, and this union is crowned by a steam vessel.

The Count de Flandre, Honorary President of the Belgian Commission, received last week, in his palace at Brussels, the members appointed by the Belgian Government, the presidents of the group committees, and the executive committee of the Exhibition. His Royal Highness, in receiving his visitors, promised his active co-operation in the forthcoming Exhibition, expressing, at the same time, his great satisfaction at the increasing number of new adhesions from foreign Governments.

The Archduke Charles Louis of Austria is at the head of the Austrian section; Mr. Rodolphe Isbary, being the commissioner. There are about 1,000 exhibitors entered already.

The Argentine Republic has voted £5,000 for the expenses of its section. The exhibits at Turin will be transferred almost entire.

A syndicate of German traders at Antwerp have secured a space of 5,000 square metres for Germany.

In the machinery gallery, the Société Bocknill will occupy a large space, with many large and powerful steam-engines, among others one of a pair of 4,500 indicated horse-power, for the Russian iron-clad *Tschema*, and many locomotives.

Among other Belgian engineers who exhibit, are Fetis and Deliege, who occupy 350 square metres; the Société de Sclessen, 150 metres; Carels Brothers, and Bollinckx, each 100 metres; M. Comez, with 50 metres, &c. Among the German engineers, the Brothers Stumm occupy 200 metres; and the Machinebau Actiengesellschaft Esener Union, 100 metres.

THE RABBIT PLAGUE OF AUSTRALIA.

Consul General Spencer, of Melbourne, referring to the multiplication of rabbits in the Colonies, which has become a veritable plague, states that from a single pair introduced for the amusement of sportsmen, there are now millions. In some instances, squatters have been compelled to relinquish their sheep runs, and to abandon their holdings. The advance of the rabbit is as noiseless and persistent as that of the dreaded phylloxera. Crossing rivers and mountain ranges, they are steadily penetrating into the interior, and it is to be feared that before long they will probably be found in every part of the colonies, occasioning heavy losses to the agriculturist and grazier, and involving expenditure for their partial suppression that will amount to millions sterling. To exterminate the pest, all the known appliances of modern science have been brought to bear, with the result, in some localities, of only checking its steady advance. Traps, poison, fire-arms, deadly gases, the dog, the dingo, and the mongoose have been brought into requisition, but hitherto with only partial or indifferent success. Government aid has been invoked, and the Parliament of Victoria, South Australia, and New South Wales have already voted nearly £210,000 for the extirpation of the plague, and in all probability will have to expend many thousands more, even to keep it within moderate bounds. When to this sum is added the expenditure of private individuals in the colonies named, as well as Tasmania and New Zealand, it will be seen that the outlay, both past and prospective, is enormous. According to the report of the Chief Inspector of Stock in New South Wales, no less than 700,000 acres in that colony are infested with rabbits. On 27 sheep runs they are said to be increasing; and decreasing on 36 stations and 44 sheep runs. About 115 men, under the supervision of inspectors, have latterly been employed in trapping and poisoning, and they are stated to have destroyed immense numbers. Of the various means employed in exterminating the rabbits, the most efficient are trapping and poisoning; phosphorised oats, and sulphide of carbon having been found especially effective. Latterly, some specimens of the mongoose have been imported from Colombo, and after being kept in confinement for some time, were turned out on some large estates in these districts in Victoria and New South Wales, where the rabbits are most numerous, and it is stated that the result of the experiment has been most favourable. Consul Spencer says that one result of this plague of rabbits has been to open up new channels of trade, and develop new industries From Victoria alone, during the year 1882, 4,929,432 rabbit skins were exported; and from New Zealand, 9,198,837, of the aggregate value of £132,000.

TURIN EXHIBITION.

The ceremony of distributing the prizes awarded by the juries to the exhibitors at the Turin Exhibition took place on Tuesday, the 4th inst., in the large Concert-room, the King and Queen, attended by the Minister of Agriculture, having come specially from Rome in order to be present.

The number of prizes awarded were as follows:—

Diplomas of honour	163
Gold medals	351
Silver medals	1,614
Bronze medals	1,894
Honorable mentions	1,782
Testimonials of merit in the gallery of labour	158
Special medals and other premiums given by the Ministers, Municipalities, Chambers of Commerce, &c.	308
	6,270

Out of the 12 diplomas of honour, 9 gold, 24 silver, 19 bronze medals, and 19 honourable mentions in the International Electrical Section, three premiums have fallen to the share of the only three English exhibitors. A diploma of honour was awarded to the Eastern Telegraph Company, Limited, for their exhibits, which included Sir W. Thomson's syphon

recorder; a gold medal to Mr. L. Gaulard, of the National Company for the Distribution by Secondary Generators, Limited, together with two-thirds of the special premium of 15,000 lire, offered by the Italian Government and the Municipality of Turin for the most important invention relating to the transport of electric energy to a distance, and its individual application. The other third of this premium, with a gold medal, was awarded to an Italian exhibitor, the "Società Anonima Italiana di minere, di rame e di elettro-metallurgia," of Genoa, for the process in operation both in the Exhibition, and on a large scale at their mines at Casarza (Settri Levante), for extracting copper from its ore by electricity.

The other premiums awarded to English exhibitors were a gold medal to Messrs. R. C. Crompton and Company, and a silver one to the Swan United Electic Light Company, Limited.

COLONIAL AND INDIAN EXHIBITION, 1886.

A Royal Commission has been appointed to advise her Majesty upon the best mode by which the products of industry, agriculture, and the fine arts of the Colonial and Indian Dominions may be procured and sent to the Exhibition of those products which it is proposed to hold in London in 1886. The list of commissioners includes the names of their Royal Highnesses the Prince of Wales, the Duke of Edinburgh, the Duke of Connaught, the Duke of Cambridge, the Dukes of Manchester and Buckingham, the Marquises of Lansdowne, Salisbury, Normanby, Ripon, Hartington, Lorne, and Hamilton; Earls Derby, Dalhousie, Roseberry, Carnavon, Cadogan, Granville, Kimberley, Dufferin, Northbrook, and Lytton; Viscounts Cranbrook and Bury; Lords Reay, Strathnairn, Napier of Magdala, and Aberdare; the Honourables Evelyn Ashley and Edward Stanhope, Sir Stafford Northcote, the Chancellor of the Exchequer, Mr. Foster, Sir W. H. Gregory, Sir Lyon Playfair, Sir Michael Hicks-Beach, Mr. Mundella, Mr. Grant Duff, Sir Louis Mallet, the Lord Mayors of London and Dublin, the Lord Provost of Edinburgh, Sir George Birdwood, Sir Daniel Cooper, Sir Frederick Haines, Sir Henry Rawlinson, Sir Thomas Brassey, Sir Dighton Probyn, Sir Joseph Fayrer, Sir Joseph Hooker, Sir Lepel Griffin, Sir Andrew Clarke, Sir Charles Tupper, Sir John Coode, Sir John Rose, Sir Barrow Ellis, Sir F. Dillon Bell, Sir Saul Samuel, Sir William Sargeaunt, Sir Peter Lumsden, Sir Oliver St. John, Colonel Yule, General Strachey, Colonel Michael, Mr. Birkbeck, Mr. S. Morley, Mr. W. G. Pedder, and many others, also several great Indian princes and chiefs, as the Nizam, the Geikwar, Scindia, Holkah, the Maharajah of Cashmere, the Maharajah of Jeypore, and the Begum of Bhopal. Sir Philip Cunliffe-Owen is appointed secretary of the Commission.

Correspondence.

WINDOW GLASS IN CHINA.

Window glass appears to be an important article, gaining every year in extension and importance. The statistics give the following figures, representing the import in Shanghai:—

1879	16,602 cases.
1880	44,638 ,,
1881	42,839 ,,
1883	55,655 ,,

Of these cases, 95 per cent. are imported from Belgium, and the remaining 5 per cent. from England, Germany, &c.; the import of these latter countries having been:—

1879	225 cases.
1880	2,700 ,,
1881	600 ,,
1882	2,030 ,,
1883	800 ,,

China does not possess a single glass manufactory, although this article is now required everywhere.

GEORG E. C. SELBERG, F.R.G.S.

19, The Grove, Denmark-hill, S.E.
17th November, 1884.

General Notes.

COMMERCIAL MUSEUMS.—The question of starting commercial museums in the principal towns which form the centres of trade and commerce has often been discussed. The French Government has recently taken the matter in hand, and has requested the chambers of commerce in the country to give their opinions as to the desirability of establishing such museums in the large ports, for the benefit of the commercial and industrial classes at home and abroad. In answer to this, the Bordeaux Chamber called attention to the fact that there is in that town a museum of the character mentioned, which has been in existence for many years. This museum contains a very interesting collection of specimens of all raw and manufactured articles of French trade, and of French colonial products, as also of building materials, tools, implements, and other objects connected with trade industry and agriculture.

MUSEUM OF HYGIENE AT TURIN.—A Museum of Hygiene, similar to the Parkes Museum in London, will shortly be opened at Turin, and extensive purchases in the health department of the Exhibition have been made by Dr. Pacchiotti, who is one of the chief promotors of this useful institu-

tion. Amongst the principal objects that have been already bought are the two models of temporary hospitals for contagious diseases, by Dr. Villa and Signor Maggi, of Misunto; the portable apparatus for gymnastics for the use of families, of Signor Campazini, of Reggio Emilia; a model of a furnace for cremation by the Milan Society for cremation; three urns to contain the ashes after cremation, of C. Riva, of Milan; and an apparatus for washing and disinfecting automatically urinals, invented by Signor Mottura. The following donations have been made to the museum by the various exhibitors:—Signor Buscaglione, of Turin, a model of his oven for disinfecting clothes, &c.; the new Waterworks Company, of Genoa, the model of the great artificial reservoir of the Defarrari-Galliera aqueduct; Signor Bertolotti, the models of houses for the working classes at Bologna; Signor Fassini, of Milan, the plans of the new working men's quarter at Porta Vittoria; Signor Pignocchi, the plans for the water supply to Osimo; the "Società di Mutuo Soccorso," of Treviglio, drawings of the co-operative kitchen established in that town; and lastly, the admirably executed collection of wax models of edible and poisonous fungi, comprising no fewer than 288 specimens, made by Cav. Maestri, and given by the King.

New Orleans Exhibition.—This Exhibition is announced to open on December 1st, and close on May 1st, 1885. It will contain the largest conservatory in the world. The Horticultural-hall is stated to be 600 ft. in length and 194 ft. wide through its centre. It is substantially built as a durable structure, and is to be a permanent feature of the park. It is located on high ground in the midst of live oak groves. Surmounting the centre is a magnificent tower, 90 feet high, roofed with glass. Beneath this tower, in constant play, is a grand fountain. Twenty thousand plates of fruit will be shown on tables extending through the hall. Around the hall will be arranged a variety of rare topical and semi-topical plants, flowers, and shrubbery. There is a tropical hothouse, 250 feet long by 25 feet wide, in which the most delicate flowers from the far South will be nurtured and made to bloom in their most brilliant perfection. Tropical fruits in the various stages of growth will be exhibited. Fruits of every section and the productions of all seasons will, by arrangements for stated supplies and thorough processes of cold storage, be available for exhibit. The most eminent horticulturists of the United States are said to be engaged in arranging and perfecting the display, and contributions to its exhibits from Mexico, Central America, the West Indies, and the different States of the Union are expected to be unprecedentedly large and varied. An International Conference of cotton growers and manufacturers, and of persons interested in the cotton industry, will be held in connection with this Exhibition in February next. The sittings will commence on the 10th of that month.

MEETINGS FOR THE ENSUING WEEK.

Monday, Nov. 24...Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. John Shaw, "Farm Tenancy Agreements in relation to the last Agricultural Holdings Act for England (1883)."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. Michael Beazeley, "Overland Journey in the Island of Formosa, from Ta-Kow to the South Cape."

London Institution, Finsbury-circus, E.C., 5 p.m. Rev. W. Benham, "The French Revolution." (Lecture III.)

Tuesday, Nov. 25...Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, Great George-street, S.W., 8 p.m. Adjourned discussion on Mr. A. Jamieson's paper, "Electric Lighting for Steamships."

Anthropological, 3, Hanover-square, W., 8 p.m. 1. Dr. J. G. Garson, "Exhibition of a Prehistoric Skull from the Island of Antiparos." 2. Dr. W. H. Coffin, "Note on the Abnormal Dentition of a Hairy Boy from Russia." 3. Miss A. W. Buckland, "Facts suggestive of Prehistoric Intercourse between East and West." 4. Mr. Horatio Hale, "Some Doubtful or Intermediate Articulations." 5. Mrs. Erminie A. Smith, "Remarks on the Customs and Language of the Iroquois."

Wednesday, Nov. 26...SOCIETY OF ARTS, John street. Adelphi, W.C., 8 p.m. Mr. Ernest Hart, "The International Health Exhibition."

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m. Mr. C. H. E. Carmichael, "The Border Land of the Middle Ages and of the Renaissance."

Thursday, Nov. 27...SOCIETY OF ARTS, John-street Adelphi, W.C., 8 p.m. (Howard Lectures.) Mr. W. Anderson, "The Conversion of Heat into Useful Work." (Lecture I.)

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 7 p.m. Rev. W. Benham, "The French Revolution." (Lecture IV.)

Parkes Museum of Hygiene, 74A, Margaret-street, W., 8 p.m. Dr. Alfred Carpenter, "Progress and Co-operation in Sanitary Work."

Telegraph-Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. 1. Adjourned discussion on Dr. J Hopkinson's paper, "The Theory of Alternating Currents, particularly in reference to two Alternate Currents connectedto the same circuit." 2. Professor W. Grylls Adams, "An Account of Experiments with Alternate Current Machines."

East India Association, Lower Hall, Exeter Hall, W.C., 2.30 p.m. General Sir Orfeur Cavenagh, "The Mutual Advantages of the Connection between England and her Indian Empire."

Friday, Nov 28...Quekett Microscopical Club, University College, W.C., 8 p.m. Mr. F. Bates, "The Supposed Sexual Threads in Zygnemaceæ."

Clinical, 53, Berners-street, W., 8½ p.m.

Browning, Prince's Hall, Piccadilly, 8 p.m. Performance of "In a Balcony," and Music by Miss Ethel Harraden, Dr. C. Villiers Stanford, Mr Edwin Bending, &c.

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FRIDAY, NOVEMBER 28, 1884.

All communications for the Society should be addressed to Secretary, John-street, Adelphi, London, W.C.

NOTICES.

INDEX TO "JOURNAL."

The new index to the *Journal of the Society of Arts*, volumes xxi. to xxx (1872-82), is now ready, and can be obtained by members on application to the Secretary, John-street, Adelphi.

Some copies of the two previous ten-volume indexes are still in stock, and can also be obtained by members on application.

The price to non-members of each index is half-a-crown.

Proceedings of the Society.

SECOND ORDINARY MEETING.

Wednesday, November 26, 1884; the Duke of Buckingham and Chandos, G.C.S.I., Chairman of the Executive Council of the International Health Exhibition, in the chair.

The following candidates were proposed for election as members of the Society:—

Bagot, Alan Charles, Royal Hotel, Torquay.
Baker, Benjamin, 2, Queen-square-place, Westminster, S.W.
Donaldson, George, 6, Bedford-square, W.C.
Hewitt, Daniel Hewson, 27, Stanwick-road, West Kensington, S.W.
Pye, James, Clovelly-house, Eversley-park, Chester.
Varley, Cromwell Oliver, Cromwell-house, Adelaide-road, Brockley, S.E.
Vine, J. R. Somers, 27, Great Winchester-street, E.C.
Waterhouse, Edwin, 13, Hyde-park-street, W.
Watson, Gerald Thomas, 131, Holland-road, Kensington, W.
Wheeler, George Robert Welby, Town Hall, Caxton-street, Westminster, S.W.
Worton, John, Blaenavon, Monmouthshire.

The paper read was—

THE INTERNATIONAL HEALTH EXHIBITION: ITS INFLUENCE AND POSSIBLE SEQUELS.

By Ernest Hart.

In undertaking, at the request of the Council of the Society of Arts, to deliver at very short notice an address on the subject of the International Health Exhibition, I am influenced far less by any sense of personal fitness for undertaking a duty which would certainly be better filled by many of the eminent persons connected with that important and successful enterprise, than by a desire to carry out the wishes of the authorities of a Society which has from the first so largely aided in the successful development of the work of the Exhibition, and in the completeness of some of the most important of its executive details, and on which there may possibly devolve important duties in connection with the more permanent memorials which that undertaking may be expected to leave behind it. The members of the Society of Arts will inherit from the International Health Exhibition one legacy at least, upon which, indeed, they have already entered, which will constitute one of the most lasting memorials of the Exhibition, and one which is destined to exercise a far reaching influence in the furtherance of popular knowledge on health subjects and the encouragement of further progress. I refer to the twenty solid volumes of handbooks, lectures, conferences, and catalogues which constitute the literature of the Exhibition. In their subject-matter they are of unsurpassed excellence, and the more they are studied, the more they will be appreciated.

Health exhibitions belong altogether to quite modern history, as, indeed, it is inevitable that they should, seeing that the science and art of sanitation, as we now study it, is of altogether modern origin, and may be said to be of chiefly English growth. Putting aside any attempt to review the history of health exhibitions in this country, I may say that I believe that the earliest attempts in that direction may be justly set down to the credit of the Social Science Association, which has, during many years, held local exhibitions of the kind in connection with its annual meetings. This association held its first exhibition in connection with its annual congress in Leeds, in 1871, followed by exhibitions in Norwich in 1873; Glasgow, 1874; Brighton, 1875; Liverpool, 1876. The Sanitary Institute held its first exhibition in 1879, and has since continued them in various great cities. The Parkes Museum, established in

1876, has since continuously developed the valuable collection formed in memory of the eminent man whose name it bears, and has successfully endeavoured, from year to year, to make this institution of increasing use by a series of lectures and meetings, which should attract to the museum persons interested, or whom it was desired to interest, in public health questions. These conferences afford an opportunity for diffusing information and for obtaining and communicating exact information on subjects relating to the public health. An exhibition of sanitary appliances, and of medical and surgical instruments related thereto, was successfully arranged by the authorities of the Parkes Museum at South Kensington in the year of the Medical Congress, 1881. So far as I know, however, the first health exhibition held in this metropolis, in the sense in which that word has been understood on this occasion, viz., health in its relation to the habitation, food, and dress, was organised by a sister society, the National Health Society, in 1883, in a large iron building at Knightsbridge, since known as Humphrey's-hall. A special exhibition, with the object of promoting the Abatement of Smoke, was held at South Kensington in the year 1881, by the Smoke Abatement Committee, and had a valuable influence on public opinion, and in stimulating the ingenuity of inventors in a direction in which improvement is much needed.

The present Exhibition was organised under circumstances of some difficulty, owing to the great pressure of time, and the difficulties which the short space of time at command interposed in the way of making the display as fully international and representative as might have been desired. My first communications with Sir Philip Cunliffe-Owen on this subject were made early in July of last year, and I have before me a very complete programme, closely corresponding to that of the present Exhibition, which, with his approval, and the valuable assistance of Mr. Redgrave, was then drawn up, after an examination of the classifications, lists, and catalogues belonging to all previous exhibitions of the kind in this and other countries. At that time, however, there was reason to believe that the buildings of the International Fisheries Exhibition would be occupied by a display of another kind, and the preliminary steps then taken, therefore, fell into abeyance. In October of 1883 (at the close of the Fisheries Exhibition) his Royal Highness, the Prince of Wales, announced his intention of organising a Health Exhibition in the buildings which had been the seat of the successful Fisheries Exhibition of 1883, in the following terms:—

"I have expressed a desire that the Exhibition of 1884 will embrace the conditions of health, in so far as, like food, clothes, and dwellings, they fall under the head of hygiene, or, like appliances for general and technical teaching, gymnasia and schools, under that of education."

These comprehensive words correspond closely and singularly with the definition which the late Dr. Parkes gave of the word hygiene:—"Hygiene signifies perfect rules for mind and body; it is impossible to disassociate the two."

The Saxon word "health" was chosen in planning the Exhibition, in lieu of the new scientific word "hygiene," for reasons which need no explanation, as being at once English and popular; on the other hand, the use of a phrase so popular, and to which a special domestic meaning has long attached, has made it easy for the numerous critics who are always at hand to correct us in our phraseology and in our acts, to achieve a superficial triumph in reviewing the numerous departments of the Exhibition by asking—"What has this or that particular exhibit to do with health?" The answer was, of course, easier than they chose to assume. Had the more technical and scientifically applicable word of hygiene been adopted, it would perhaps not have been so easy to the most captious critic to ask what have food or dress, or any element in the construction or fittings of the dwelling, to do with hygiene; for just as sanitation is a modern science, so is hygiene a modern word, which most briefly summarises the scope of modern sanitary endeavour. A Health Exhibition it was, in so far as health may be accepted as the synonym of "hygiene."

I shall not fatigue you by a recapitulation of the departments, or an analysis of the classification. The heads under which the various exhibits were shown may be summarised as food, dress, the dwelling, its contruction, and fittings; water supply and sanitation, heating, lighting, and ventilation; the ambulance, the workshop, the school, and technical education.

The programme of the International Health Exhibition was properly, and even necessarily, so wide, that to attempt to deal with any considerable proportion of it in detail, in the short space of time to which a paper such as this is rightly limited, would reduce the character of any observations which could be made to that of a mere synopsis which would

have much of the character of a catalogue, and would therefore be foreign to the objects we set before us in a meeting such as this. I think that I shall be making the most useful employment open to me of the time at command this evening, if I limit our consideration to-night, of the Exhibition which has just closed, to a small and selected number of topics, among those—and they are many in number—which the Exhibition seems to me to suggest in respect to the consideration of its past usefulness. Especially also I wish to refer to the useful sequences which may practically result from it in various directions, by the active impressions which it made upon a number of the scattered organisations in this country possessing health functions, and upon the great body of the people, to whom we must look for support in the departments of sanitary progress which the Exhibition revealed to us as being in most pressing need of practical development.

Executive Council and Committees.

Before passing, however, to consider those particular features in the Exhibition from which, it seems to me, its useful influences have resulted, and will in the future flow, I think you will agree with me that it is not unfitting that I should give some idea of the nature of the organisation by which so great a result was effected, and of the work done in the different departments. I shall neither affect nor attempt to give this in complete detail. The Official Report which the Duke of Buckingham, the Chairman of the Executive Council, is engaged in preparing, and will shortly present to his Royal Highness the President, will no doubt set out, with accuracy and completeness, the chief facts connected with the working of the organisation over which his Grace has presided with such indefatigable assiduity, comprehensive knowledge, and singular attention to business detail.

You will, I am sure, however, think it right that I should remind you that immediately on their appointment, the Executive Council lost no time in organising a series of sub-committees and divisional sub-committees—seventeen in number, and including persons best known for their thorough information in each of the classes represented in the Exhibition. These sub-committees drew up a series of memoranda for the guidance of exhibitors, which are in themselves highly interesting and valuable documents, and will continue to have a permanent value for the guidance of all who may undertake a similar enterprise in the future. These memoranda are to be found prefixed to all the editions of the catalogue, and tend to make that catalogue what it will long continue to be, an almost indispensable work of reference to whoever would have at hand a classified list of the objects which at the present time illustrate in the best manner our most advanced knowledge of applied sanitation in all its departments. The Executive Council met continuously, at least twice a week, for a long series of months, and with the invaluable aid of the sub-committees, and of the well-trained, able, and zealous executive staff placed at their disposal, they succeeded, in a short space of time, in making all the necessary arrangements.

Foreign Contributions.

With foreign countries it was difficult, within the limited space of time at disposal, to make the necessary communications, and to convey the information they required, in order to induce them to take an active part in the Exhibition. In this object also an unexpected success was attained. Distant countries, such as China, were communicated with by telegraph, and—thanks, in a great measure, to the singular energy and goodwill of Sir Robert Hart, Mr. Campbell, and the Chinese Commissioners of Customs, and to the courageous initiative of Sir Philip Cunliffe-Owen—China undertook and carried out an exhibit of unique interest, in respect to a practical display of its food resources and culinary peculiarities, as well as of much that was picturesque, if not of scientific moment, in relation to the dwellings and the clothing of that most interesting nation. Thanks also to the active intelligence and courtesy of the Japanese Minister, Mr. Mori, the Japanese Government became, at a somewhat late date, warmly interested in the objects of the Exhibition, and they furnished a display of quite unsurpassed interest both in all that relates to scientific sanitation, in which this remarkable nation has made astonishing progress, and in respect to the illustration of the dwelling, clothing, and domestic arrangements of the people, as well as to the development of decorative art in its relation to the house. The Japanese Commissioners, Mr. Nagai, Mr. Tegima, and Mr. Murai, were, from the moment of their arrival in this country, quite indefatigable, and singularly successful in their endeavours to make the unique display which the Japanese Govern-

ment so liberally forwarded to this country thoroughly intelligible and profoundly interesting to all the visitors to the Exhibition. To this remarkable liberality and ability with which the Chinese and the Japanese Governments despatched and organised their contributions to the International Health Exhibition, was due one of its most attractive and novel features. Nothing had ever before been seen in Europe which could convey with so much picturesque accuracy, a correct idea of the food, clothing, sanitation, and educational arrangements of these two great Asiatic nations as that which was seen in this Exhibition, in the Chinese and Japanese courts, and the restaurants attached to them. The special catalogues, published by the Commissioners, are in themselves contributions of unique interest to the literature of the subjects illustrated by the Exhibition. Those who do not possess them, or who have not studied them in relation to the exhibits displayed, have lost an opportunity never before afforded, and which can hardly again recur, of obtaining an insight into the intimate life of these distant and marvellously organised countries, such as everyone not destitute of an ordinarily intelligent curiosity must desire to possess, and must have felt infinite pleasure in acquiring. If I may be allowed to say a word for that nation, for which I feel a peculiar and almost affectionate admiration, I would say that the history of the world shows nothing which can compare in kind with the rapidity with which the Japanese people have mastered the principles and practice of scientific sanitation; or with the unexampled capacity which they have shown for rapidly appreciating, and accurately applying to the conditions of their own country the results of European science and European practice in all that relates to public health and to the sanitation of the house. Those who have studied the reports of the sanitary and meteorological bureaus which were shown in this exhibit, will know that I am not exaggerating when I say that at the present moment Japan includes among its native citizens many persons who are to a great extent, and on a great variety of the most difficult questions of hygiene, as thoroughly informed and as soundly inspired with the principles and practice of hygienic science as any of our most advanced European professors. Of course, the whole resources of civilisation have not been equally applied to all parts of Japan, and there are still to be found there the most remarkable contrasts of an ancient Asiatic civilisation in immediate contact with the last results of European scientific knowledge and practice. The centres of government are, however, evidently penetrated with a strong sense of the importance of extending throughout the whole empire of Japan those principles which are so well understood at the centre. It was with great satisfaction that the Executive Council received, near the close of the Exhibition, from the Japanese Commissioners the expression of their desire that the Council should furnish them with a report, by an expert, upon the ordinary dietary and dietetic materials which constitute the staple of the daily food of the population of Japan. With this request they were happy to comply, and Professor De Chaumont has undertaken to furnish the required report. Meantime, with characteristic industry and practical sense, the Japanese Commissioners have studied for themselves the exhibits of other nations in the Exhibition, and have effected exchanges which will on the one hand enrich one of the European nations —not, I am sorry to say, our own—with many of the most characteristic of the Japanese exhibits, and, on the other hand, will transfer to Japan the corresponding exhibits of the Austrian Government.

In regard to other foreign nations, I shall pass lightly over the brilliant display of Siam, which arrived late, and for which we are much indebted to the influence of Mr. Satow, our recently appointed minister in that country, whose unrivalled erudition and intimate acquaintance with Eastern literature and customs give to all his work a special *cachet* of learning and distinction, which have made his name known in every country where European scholars study Eastern customs with anything like seriousness or depth of research. Of that display we have reason to hope that some of the most interesting parts will, by the liberality of the Siamese Government, be secured for public use.

Among the European countries, the display made by France held naturally and justly a most prominent position. It was not until January that any movement was made by the French Government to assist in carrying out the wishes of the Executive, or in reference to communications made through the Foreign Office. For the remarkable completeness of the French display we are indebted largely to the active assistance of the authorities of the Société de Medecine Publique in Paris, who aided me greatly by their vigorous representations to the Ministry of Commerce and of Public Instruction (when I visited Paris for the purpose

in January), as to the great importance that France should take a suitable part in this Exhibition; but it is doubtful whether such representations would have been effective but for the subsequent presence of Sir Philip Cunliffe-Owen in Paris, and the activity which his great personal influence there was able to give to the preparations then commenced. Although late in beginning, the French display lost nothing, thanks to the liberality of the grant made by the French Government, and the skill and energy of the eminent persons who were nominated by the Ministers and by the Prefect of the Seine, to form a French Commission. Dr. A. J. Martin, Commissaire-General, devoted himself, at great personal sacrifice, to the arrangement of the numerous exhibits of France in a thoroughly scientific order. It is impossible that I should do more than refer to the principal elements of interest in the highly instructive and scientific section which was filled by the Ville de Paris, and by the public institutions of France, but no section in the whole Exhibition was more worthy—none, I will venture to say, so well worthy—of careful study as the display of France. I omit at the moment any detailed reference to that which was the gem of the whole collection, viz., the display of M. Pasteur, because I shall have occasion presently to refer to it in further detail.

Italy, which up to the month of February had remained unmoved by the official representations transmitted through the Foreign Office, was, however, induced by the personal intervention of his Majesty the King of Italy, and the liberal and patriotic action of the municipality of Rome, led by the Duke Tortonia and the Marchese Vitelleschi, to enter actively into the spirit of this great display. I had the honour of an interview with the King in the month of February, together with Mr. Harold Acton, who was sent out by the authorities at South Kensington with the purpose of assisting in awakening interest in the objects of the Exhibition in Italy, when the King entered very fully into the details of all that was required, and authorised a public statement of his personal interest in the undertaking, and his desire that Italy should fully participate in the valuable enterprise which his Royal Highness the Prince of Wales had organised. This public declaration of the wishes of the King, who takes the most lively personal interest in all the affairs of his country, and enters minutely into the business of public offices, was of immense service in facilitating our subsequent proceedings with the public ministries. No one who entered the Italian Court but must have been struck with the profoundly interesting display of the works of sanitation belonging to the old Roman period. The arrangements for baths, for water supply, and for drainage, in the ancient city of Rome, put to shame those of our modern London, or, indeed, of any modern European city, and form a model on which Rome and its municipality are endeavouring once more to reform their public water supply and drainage. Rome has greatly benefited within the last ten years by the spirit of modern sanitary science; the water supply of Rome, its drainage, the sanitation of the surrounding country, the construction of its public buildings and institutions, the provision of ambulance arrangements for the sick, all offer features of very great interest. These were illustrated by many most interesting models, plans, and designs, and I am glad to say that many of these will probably remain in this country. The food resources of Italy, and its great and growing power of adding to the dietary of the table of our own country and of other European countries, was well exemplified in this court by the exhibits of the Circolo Ænofilo, to whom that country is largely indebted for the development of its exportation, as well as by private exhibitors. I do not think we can express too warmly our satisfaction at the valuable contribution which Italy made to this Exhibition. I am sure that Englishmen feel a peculiar pleasure in witnessing the marvellous growth of commercial energy and scientific education in united Italy. Their wines, of which enormous quantities are at the present moment imported into France and other wine-growing countries, for the purpose of mingling with their vintages, and of being re-exported to us under names well established in our markets, have a character of genuineness and special merits of their own, which only require to be better known in this country in order to assume their rightful place in public favour. One result to which we may look forward in connection with this Exhibition, is a large increase in popular acquaintance with the merits of the Italian food supplies, her cereals, her pastes, and her wines. Certainly such a result is well deserved, from their intrinsic worth, as well as from the public spirit with which the principal chambers of commerce and public bodies, as well as individuals, responded, under great pressure of time and no small public sacrifice, to the appeal which reached them at a very early date. The

contribution of Italy to the Exhibition was one of its greatest and most genuine attractions.

Belgium early, if not, indeed, first, among European nations, demonstrated that enlightened interest in sanitation with which she has for some years been rightly credited, by applying for a considerable amount of space, which she worthily filled. There is no one who is acquainted with the history of some of the most important questions of public health, who does not know that the City of Brussels offers in many respects a model which we and all other European countries would do well to follow. Under the direction of Dr. Jansens, a central bureau of hygiene in Brussels is so arranged that every case of infectious disease is immediately notified to him, the circumstances which call for public intervention or which make it unnecessary being at the same time stated. Every such case is at once pricked off on maps with coloured pins, so that he is enabled to follow the march of infectious disease just as a general the march of his troops. To Belgium, also, we owe chiefly that practical experience, and that scientific study of vaccination direct from the calf, which has enabled us to determine means by which the objections which some persons entertain to vaccination from arm to arm may be avoided. It was to Brussels I found I had to go, now four years since, when I wished to study this subject, with the view of inducing our Government to introduce vaccination from the calf as a State institution in this country, a result which has since followed. It was from Brussels that we invited Dr. Warlomont to come to London, to give us the result of his Belgian experience, and to the information thus gained, and to the experience acquired in Belgium, we mainly owe it that we have now established in this country a system of vaccination direct from the calf as part of our public institutions. We are thus under a debt of no small magnitude to these enlightened sanitary administrators. All those elements for guarding health and the protection of infant life, for the sanitation of factories, for the education of the deaf and dumb and blind, which the Exhibition was designed to bring into prominence, were illustrated in the Belgian Court in a manner which could not fail to be profoundly instructive to those who sought for serious studies in this Exhibition.

To the other exhibits it is impossible for me to refer, seeing the very restricted canvas on which alone I can allow myself to might to sketch. The able and extended survey which Sir Frederick Abel took last week, in his opening address, of many of the departments of the Exhibition, his study of the more important conferences and lectures which were given, will dispense me from the necessity of referring to a great variety of topics which could not properly be excluded from any paper, however condensed, or however limited, treating of the Exhibition. They have already been referred to with so extended and so discriminating appreciation by our eminent chairman, that I shall say but little of the general aspects of our English display. I cannot, however, refrain from joining with him in a tribute to the remarkable interest of that picturesque range of buildings illustrating the habitations, the technical education of Old London, which we owed to the liberality of the Corporation and to the City Guilds, and especially to the initiation of the City Chamberlain and to the untiring energy of Mr. Shaw, who, as Chairman of the City Committee, devoted himself with unceasing labour to the development of an idea which he was one of the first to accept, and which he carried out with the aid of Mr. Birch, Mr. Gardner, and others, with a completeness and a rapidity which astonished everyone. Nor is it possible to omit the reference once more to that complete and brilliant display by the water companies, under the superintendence of Sir Francis Bolton, which, whether in its purely hygienic aspect as affording a survey of the enormous organisation by which London is supplied with water, or in its holiday character, as seen at night in the illuminated fountains, was the talk of London throughout the season, and drew crowds to the building.

London Water Companies.

The metropolitan water companies appeared in a new light at this Exhibition, and entered the arena as caterers for the pleasure, amusement, and instruction of the public. Candour compels us to admit that they succeeded most admirably, thanks, in a great measure no doubt, to the able supervision and energetic initiation of Colonel Sir Francis Bolton, with whom, and Sir Philip Cunliffe-Owen, the idea of having a waterworks exhibit originated. The proposal was no sooner made than acted upon, and H.R.H. the Prince of Wales received, in answer to a letter written by him to the various water companies, the most hearty assurances of co-operation from the companies.

A sub-committee was then appointed, under

Sir Francis Bolton, consisting of Professors De Chaumont and Frankland, Brigade-Surgeon Dow, Mr. Michael, Q.C., Mr. S. H. Louttit, Mr. Philip A. Scratchley, Mr. A. T. Simpson, C.E., Dr. T. Stevenson, Mr. J. Taylor, C.E., and Col. Webber, R.E., C.B.; and to this body the engineers of the respective companies were subsequently added. As explained in the letter of His Royal Highness, the exhibit embraced all that related to the sources, collection, and filtration of the London water supply, together with house storage, economy and waste of water, and its uses for every domestic purpose.

The principal portion of the display found an abode in a building constructed in the form of a regular octagon, with an annexe adjacent to the Prince of Wales' Pavilion. The difficulty experienced was to make the specimens and objects exhibited sufficiently attractive; in other words, "to invest them with artistic merit," and the Committee ultimately resolved to decorate the structure, so as to assimilate it as much as possible with the characteristics of the rivers Thames and Lee, and the general sources of the metropolitan supply.

The pavilion was specially constructed for the purpose of this collective exhibit, the object of which was to show the manner in which the inhabitants of London are supplied with water, and to convey to the general public as clear an idea as possible of the magnitude and importance of the metropolitan water supply. The octagonal shape was adopted, in order that each company might have one side of the octagon for its exhibits.

In the outside annexe the special exhibits of each company were shown, and at regular intervals there were specimens of the various large mains used in the metropolis, varying in size from 13 to 48 inches, as well as water meters and hydrants. The number of miles used in the metropolis was painted on each specimen.

In the retiring angle to the south of the door was a specimen of a flexible pipe, as used by the Southwark and Vauxhall Company; and in the retiring angle to the north was a complete section showing a large main as laid in a London street, with all the necessary cocks and appliances. There was also a complete section of a house supplied with fittings in accordance with the requirements of the Act of 1871.

In a garden specially attached to and adjoining the Water Pavilion was a separate building, which contained specimens of various laboratory apparatus used in making analyses of water by different systems.

In connection with the collective exhibits was a fountain display, beneath the Prince Consort's statue in the garden. An island was constructed in the centre of the basin, on the middle of which was a large jet surrounded by small fountains and aqueous plants. This island served for a subaqueous cabin, in which were placed the aqueous and illuminating apparatus. The whole of the basin was laid out in fountains capable of illumination, and water plants and a border of jets surrounded the basin.

The cascades were also worked at the same time as the fountains, the whole of which were illuminated by electric lights, so as to produce appropriate changes of colour. The principle of this illumination was the fact that a stream of water can be illuminated internally, by causing the jet of water to issue from a hole in the side of a receiver through which a powerful beam of light is thrown from the other side. The light thus struck the internal surface of the jet, and was totally reflected. The effect of this was to keep the light within the jet, which was thus illuminated within throughout its whole course, and in the dark resembled a stream of fire.

Great assistance was given to Sir Francis Bolton by the engineers of the water companies, who acted on the sub-committee for carrying out the arrangements.

Not the least attractive feature of the very attractive exhibit, which reflects the greatest credit, was the collection of old prints and documents associated with the history of the various water companies. Sir Hugh Myddelton was naturally to the front in many ways, but no one could have anticipated that the name of Pepys would in any way be associated with the water question, yet the New River Company exhibited a water-rent receipt for water supplied to the famous diarist in 1706.

Food Department.

Referring generally to that great bulk of the Exhibition which was occupied by English exhibitors, I would say that, while much reference has been made to the apparently miscellaneous character of many of the exhibits, I know that much care was taken that not one should be admitted which had not an immediate reference to the prescribed programme, and of which the *raison d'être* was not easy to discover. It was perhaps,

however, from one point of view, open to exception that the great central avenue should have been taken up with the food display, in which the commercial interest was mainly predominant, and as to which the scientific importance was only determinable when the work of the juries came into play. By these the relative values of the articles exhibited was subjected to a searching test, such as certainly has never before been applied to the ordinary commercial articles of food publicly offered in this country, and to which it is greatly to the credit of the exhibitors that they willingly submitted. There is only one exhibit in this department to which I would specially call your attention, it was that from the collections of the Science and Art Department and the Parkes Museum, illustrating the constituents of food and food values, and the connected exhibit by the Society of Public Analysts, of materials used as adulterants of articles of food; of adulterated articles of food commonly sold in this country; of adulterations which have been suppressed; of adulterations practised abroad, and mixtures generally protected by labelling. This latter was added in consequence of a suggestion made by the late Mr. Wigner, president of the Society of Analysts, at a late date in the progress of the Exhibition. I am afraid that it did not attract all the attention that it deserved. I trust, however, we shall be able to reserve it for continual public reference. Mr. Wigner, in communicating with me, pointed out that although the Exhibition was most successfully arranged so as to display in a prominent manner all the articles connected with food, yet the public were only shown what is done by the most careful and respectable firms, whose names are a sufficient guarantee that only materials of the highest quality are used in the preparation of the goods which they show.

All who are connected with food produce know how, from time to time, the desire on the part of the consumer for cheap goods is the cause of the introduction of articles called "substitutes," which are offered to the manufacturer at one-third the price of the genuine material, and which frequently consist of some cheap and simple preparation, the very opposite in its chemical character to the article for which is said to be an efficient substitute: several cases of this kind had recently been brought to Mr. Wigner's notice. For instance, he referred to an article to be used as a substitute for tartaric acid, the composition of which has been found to be acid sulphate of alumina in solution—a substance which, if introduced into the manufacture of bread or biscuits, is as objectionable as alum, and quite as much an adulterant. Bisulphate of potash is also sold under a name similar to tartaric acid, and is equally as worthless as sulphate of alumina. These are only two instances out of many, and serve as an additional argument to show the keen competition in trade, which causes the manufacturer to produce, and unscrupulous firms to sell, such articles under "Royal Letters Patent," or some other heading of this sort, to attract the notice of the consumer.

The public analyst, Mr. Wigner added, although, of course, he should be cognizant of these facts, has quite enough work for the remuneration paid to him, and in addition to this, there is the fact that the Sale of Foods and Drugs Act is so limited in its aim and scope as to practically prevent the analyst from testing anything but the common articles of food, such as bread and milk, unless they are sold under some recognised name. Let him once travel outside these lines, and a whole host of objections are raised. What is really wanted is more stringent legislation, similar in character to that at present in operation in the United States and Paris.

In the French Section were shown the monthly reports of the Municipal Laboratory, showing the complete and thorough manner in which the food supply of that city is protected. Why cannot something of the same sort be done in London? What is wanted is a measure defining what is and what is not adulteration, and prohibiting the use of articles which are frequently employed at the present time, and the sale of which while benefiting one class seriously injures another, by substituting an inferior article for one of better quality.

Considerable good, it may be hoped, was done by the Health Exhibition by the exhibition of these so-called substitutes. The prominent display of this instructural series in a National Exhibition has, we trust, done something towards putting a stop to a trade which, while it enriches the unscrupulous trader, places the honest manufacturer in an awkward position.

How far it has fulfilled this intention is of course not yet apparent, but I shall certainly feel it a part of my duty in another capacity, as Chairman of the Parliamentary Bills Committee of the British Medical Association, to endeavour to keep the attention of our legislators to this important subject. It may be hoped

that, when the political horizon is sufficiently cleared to enable Parliament to devote some time to interests of almost as important, if less strictly party character, as those which are now occupying their attention, that it may be possible to secure for the people of England, or at least for the people of this metropolis as an example to other great towns, some of those better securities against the adulteration of food which this country was the first to set the example of creating by legislative action, but as to which it has, at the present moment, fallen behind some of those countries which followed us, such as France, Belgium, and America. It is within my knowledge, and in fact within my personal experience, that in all those countries our English legislation was originally the model which they set before them. In fact, in the case of several of these countries, I have had the opportunity of receiving the gentlemen who had been sent over by their various Governments, and of furnishing them in several instances with the opportunities of study and materials of which the respective Governments have availed themselves to create model laws respecting adulteration; I would refer here especially to the German code.

It is hardly to our credit that we have allowed ourselves to be distanced in a race in which we had so considerable a start, and in which the sole goal is the public benefit, and the maintenance of the public health. These are questions largely affecting the health of the whole nation, and especially affecting the welfare of the poor, who suffer most by the substitution of worthless, inferior, or adulterated articles in the fabrication of apparently cheap, but often very dear because worthless, articles of food.

Executive Staff.

I would ask your leave now to put before you a few figures which have been furnished to me by the heads of the departments of the Exhibition, to whom I applied for information, which should, in familiar way, illustrate the enormous amount of work which they carried out in their departments, and which alone enabled this undertaking to be organised with such singular success, on so large a scale, and in such a short space of time, and to be carried out without, so far as I know, one single hitch of any importance through the whole of the time it was open to the millions who visited it. Mr. Edward Cunliffe-Owen, the able and energetic secretary, tells me the work of the secretarial department commenced with the very first meeting of the Executive Council. The secretary attended personally every meeting of the Council, kept the record of their proceedings, and took the necessary action on their decisions. He also superintended, in conjunction with Mr. Trueman Wood, the formation and the meetings of the various sub-committees which were called together to assist the Council in their labours. He issued circular letters to foreign powers, to their representatives in this country, to the mayors and local corporations in England, and to many others, calling attention to the Exhibition, and superintended the preparation and issue of the prospectus at home and abroad. It has been the duty, too, of the secretarial department to see the numerous visitors who called, and to explain to them any questions in connection with the Exhibition, and later—when the various sections of the general superintendent's department were formed—to direct them to those who could give more detailed information.

In addition, a very large amount of correspondence of a very miscellaneous character has been maintained. No fewer than 20,000 letters have been received by the secretary from the 3rd of October, 1883, to the 20th of November, 1884; and about the same number—exclusive of circulars—have been despatched by him.

The secretary controlled the issue of exhibitors and attendants' passes, the advertising of the Exhibition, the daily programme of the arrangements of the Exhibition; and was the means by which the decisions of the Executive Council were made known to the various branches of the executive staff, and to all whom they concerned.

As affording some idea of the amount of work connected with the general superintendence department, I am informed by Mr. Hake, the courteous and indefatigable general superintendent, that 5,000 cases, registered and numbered, were received and deposited at the various stands, and some 7,000 exhibits, in the way of appliances and materials, were passed into the buildings, independent of 5,000 conveyed by hand previous to the opening. In the first three days of the closing of the Exhibition, over 1,000 vans passed in and out of the Exhibition.

Jury Department.

The manner in which the jury work was to be conducted was a matter of long and care-

ful consideration by the Executive Council. Eventually, on the recommendation of the Council, H.R.H. the President appointed from amongst its members a commission of five, who might take special charge of the work. Mr. H. Trueman Wood, the Secretary of this Society, and Mr. Gilbert Redgrave, were appointed joint Secretaries of the Commission. The Commission held its first meeting on March 28th, and in accordance with the wish of the President, prepared a scheme by which the exhibitors themselves should have the opportunity of nominating the jurors. In answer to an application to this effect addressed to the English exhibitors, nearly all of them sent in the names of persons whom they considered specially qualified to act as jurors in the classes with which they were concerned. From these lists a selection was made, and it may be said that, in every case in which any individual received the suffrage of as many as four exhibitors, he was appointed if willing to serve. It often happened that there was not sufficient unanimity amongst the exhibitors to guide the Commission in their selection, and they were, therefore, obliged to rely on their own judgment in making the remaining appointments. It was felt that the appointment of foreign jurors had better be left to the Commissions appointed by the Governments of countries taking part in the Exhibition. The commissioners were informed of the means which had been taken to elicit the opinions of English exhibitors, and it was left to them to act as they thought fit as regards the appointment of representatives of their own countries. Jurors were consequently appointed by the Commissioners representing Austria-Hungary, Belgium, France, Italy, Russia, and the United States. Eventually 28 juries were appointed, amongst whom the 57 classes of the Exhibition were apportioned. The formal inauguration of the jury work took place on June 17th, when a meeting, at which H.R.H. the Prince of Wales presided, was held in the Albert-hall. The actual work commenced immediately after this, chairmen of the juries being appointed by the President, and vice-chairmen and reporters by the juries themselves. Their meetings were carried on with very little intermission until the middle of August. By that time most of the work was completed, though that of some of the juries was not finished until shortly before the close of the Exhibition itself. It would be difficult to speak too highly of the way in which the jurors discharged their unpaid duties, and especially of the way in which those gentleman who consented to act as reporters to the various juries devoted valuable time and attention to the work. On the whole, there seems every reason to believe that the very difficult and laborious work of distributing the awards has been as judiciously performed as could possibly be hoped. The work is naturally one of great difficulty and considerable delicacy, and it is obvious that, speaking generally, only those exhibitors are likely to be satisfied who receive the highest awards. Under these circumstances it is a matter for congratulation, not only to the Jury Commission, but to the Executive of the Exhibition, that so little fault has been found with the decisions of the juries, although some complaints, and no doubt some errors, are inevitable. Let us hope that they have been reduced to their absolute minimum. To that end great efforts were made. It may be useful to put on record the fact that, after some consideration, it was determined that there should be five classes of awards:—Diplomas of honour, gold, silver, and bronze medals, and special certificates of thanks. In addition to these there were special prizes offered by the Society of Arts, with regard to which the juries were requested to make recommendations. The total number of awards made exceeds 1830, of which about 200 are diplomas of honour, 270 gold medals, 580 silver medals, 670 bronze medals, and 100 special letters of thanks. These awards were made quite independently of the Executive Council as a body, and by the juries and commissioners appointed by the President. The total number of exhibitors exceeded 3,000. In addition to the personal examination made by the juries of all exhibits—and it is worth mention that not a single complaint has been received from any exhibitor of his goods not having been inspected—a considerable number of tests and analyses were made by the juries or under their directions. In the case of the electric lighting jury, it was considered wise to institute tests for incandescent lamps which would extend over a considerable space of time, and, therefore, any awards to be based on these must of necessity be postponed. Special arrangements have been made with the executive of next year's Exhibition of Inventions, by which they have undertaken to carry on these tests, and to make awards upon them. A great number of analyses were made of foods, soaps, paints, varnishes, &c.; and many of the materials employed for house decoration, such as wall papers, hangings,

carpets, &c., were chemically examined, for the purpose of ascertaining whether they contained ingredients likely to be harmful to health.

The testing of exhibits in Classes 24 and 25 —Heating and Ventilating—were carried out on a considerable scale. Some 120 kitcheners, some burning solid fuel, and some gas, were tested. A large house was rented for conducting these trials, under conditions approximating to those which would be found in the actual use of the apparatus by the public, and a large number of tests of cooking joints, &c., in the kitcheners, &c., were made. The importance and necessity of exact testing, initiated by the Smoke Abatement Committee of 1881, and since carried on in a systematic manner by the National Smoke Abatement Institution, were fully recognised by the Executive Council of the Health Exhibition. The series of testings were conducted by the acting engineer to the Smoke Abatement Institution, Mr. D. K. Clark, and the jury of the Exhibition dealing with these exhibits included Professor W. Chandler Roberts, Mr. Robert Harris, president of the Gas Institute, and other members of the Smoke Abatement Institution whose special knowledge peculiarly fitted them for the work.

The practical advantages of such testings have been manifested in the great interest taken by exhibitors in the work, their general desire to submit their manufactures for testing, and the evidently accelerated course of improvement in design since the Smoke Abatement Committee first introduced the system of tests, and advanced knowledge derived from the results of those tests.

At the Health Exhibition, these beneficial influences were clearly traceable in the adoption of good ideas embodied in apparatus shown at the Smoke Abatement Exhibition, in 1881, and brought into notice by the testing treatments adopted there, as well as in the rejection of plausible but impracticable methods of heating and ventilation which found place in the earlier exhibition. The detailed report of the tests of the apparatus shown at the Health Exhibition I trust will be published, for it will form a valuable addition to a continuous and advancing series of tests. The importance of this branch of my subject can hardly be exaggerated. We can follow, in the light of the knowledge derived from the result of the later tests, a regular and most encouraging course of improvements. For example, some of the exhibits shown at the Crystal Palace Exhibition last year, in the class of gas-cooking and heating stoves, were proved to have a greater efficiency, by about 20 per cent., than those shown at the Smoke Abatement Exhibition in 1881; while at the Health Exhibition the efficiency proved by the tests was fully 25 per cent. greater than at the original Smoke Abatement Exhibition. Besides this increased efficiency, or improvement, to be measured by lower consumption of gas for equal work done, there has been an improvement hardly less important in numerous points of detail, affecting both the durability of the apparatus, and the facility with which it can be cleaned. These latter improvements, added to the lessened price of gas, and the reduced consumption of it in the newer forms of stove, cannot fail to tend towards the increased use of these cleanly conveniences and smokeless heating appliances for domestic purposes.

The testings at the Health Exhibition brought out the merits of a number of kitcheners and stoves very well adapted for using coke and "slack," or small coal, as well as improved patterns for using the ordinary lump coal, with lessened production of smoke. In regard to the advance made in smoke prevention from domestic fires, I may mention, on the authority of the testing engineer, that the highest average smoke shade proved by the tests of 1882 was 4·18 from kitcheners; and in the test at the Health Exhibition, the highest average was only 2·4; and from open grates, the average density of the smoke was 3·0 in 1882, and at the Health Exhibition it was only 1·75. The importance of facilitating, by means of improved apparatus, the use of coke and the cheaper fuels now generally wasted is obvious, and I think I may fairly claim that this section of the Exhibition achieved a highly useful and successful result. In the bakeries department no less than five distinct systems of heating bakers' ovens, practically without the production of any smoke whatever, were shown—and not only shown, but were proved, by an extended course of actual working, to be more or less well suited to the requirements of the trade. Varieties of machines for making dough by cleanly and expeditious methods were successfully worked throughout the period of the Exhibition; and it is but reasonable assume that the exhibition of these machines, shown daily in satisfactory working, must have a great future influence in putting a stop to the laborious and filthy process of making dough by manual labour.

Education Section.

The Education Section of the International Health Exhibition was opened on June 25th, by his Royal Highness the Prince of Wales, on the occasion of the formal opening of the Central Institution of the City and Guilds of London Institute.

It had been originally intended to arrange all the educational exhibits in the rooms kindly lent by the Committee of the City and Guilds Institute, but the space applied for was so greatly in excess of that available, that it was necessary to divide the exhibits. School furniture and apparatus and appliances for instruction were placed in the gallery of the Royal Albert Hall. Exhibits relating to the heating and ventilating of schools, school sanatoria, &c., and gymnasia, were placed in a separate court; and the rooms in the City and Guilds Institute were reserved for exhibits by institutes and societies, for the exhibit of the French Ministry of Public Instruction, and for objects connected with technical education.

Infant teaching was admirably represented by the Kindergarten established by the British and Foreign School Society, under the direction of Mr. Browne and Fräulein Heerwart. Weekly demonstrations were given to classes by experienced teachers, and the Kindergarten was so arranged that the visitors could easily see and hear the teachers and children. As soon as these demonstrations became known, great numbers of people visited them, and there can be no doubt that the Kindergarten system has attracted considerable attention, and received a decided stimulus, in consequence of the enterprise of the British and Foreign School Society.

On the occasion of the final demonstration, which took place in the west theatre of the Royal Albert Hall, the room in the Institute not being large enough, a class of about sixty School Board children received instruction, and a conference of Kindergarten teachers held.

Elementary instruction in England was well represented by the School Boards of London, Edinburgh, Glasgow, Birmingham, and Sheffield.

The London School Board showed a very complete collection of furniture, appliances, and results of instruction. Most attractive were the illustrations of the teaching of cookery given daily in the "Centre" established by the Board in the Exhibition. Here, under the superintendence of Miss Burrows and Miss Worsnop, classes of children from Board schools received practical instruction in elementary cookery.

The Birmingham School Board exhibit contained, amongst other objects of interest, sets of apparatus illustrative of the itinerant system of science instruction which has been elaborated for the Board by Mr. W. J. Harrison. This system was originally suggested by Colonel Donnelly, to obviate the difficulty of expense on account of apparatus connected with the teaching of elementary science in Board schools.

The Sheffield School Board sent drawings and specimens of work in wood and iron from their Central School, which has been established to provide elementary technical instruction. The action of the Sheffield School Board in this direction cannot but be watched with extreme interest, by all concerned with the improvement of mechanics and engineers in the theoretical knowledge connected with their trades.

The French Ministry of Public Instruction exhibited a very complete series of approved apparatus, appliances, and examples of results of instruction in infant schools, primary schools, technical schools, and training colleges.

Many of the specimens of technical work in wood and iron, from the primary and higher primary schools, were remarkably good. The drawings exhibited, as examples done by candidates for the certificate to teach drawing, were of great excellence.

Most remarkable were the sets of apparatus and objects for teaching zoology, and physiology, chemistry and physics, as granted to the training colleges in France by the Government.

The Brothers of the Christian Schools exhibited results of teaching from schools in France, Belgium, the United States, Canada, &c. A representative of the society was always present in the room, to give visitors the fullest information regarding the wonderfully complete system of elementary education organised by the Brothers. Especially noteworthy were the appliances for teaching geography, the hypsometrical charts of the Brother Alexis, and the remarkable series of drawing copies and models used in their elementary and technical schools.

The technical work from some of the more important schools, such as St. Nichlas, in Paris, were of a very advanced description.

Most noteworthy also were the numerous school museums of a local character, contributed by various schools, consisting of natural

objects, and of specimens illustrative of various arts and manufactures.

A number of very important exhibits were sent by technical schools in France, Germany, Austria, and Switzerland. The Kwestgewerbe Schule of Karlsruhe sent a remarkably fine series of drawings, decorative paintings, specimens from the wax-modelling and wood-carving classes, models in plaster, &c.

The Wood-carving School of Furtwangen also sent some fine specimens of students' work. Würtemberg sent collections from the Building School, Workmen's School, and from the Schools for Needlework and Embroidery, at Stuttgart and Reutlingen. The Austrian schools sent specimens of work from the courses for cabinetmakers and joiners, basket weavers, &c. From the Industrial Art Schools at Geneva came specimens of work in wood, iron, bronze and silver.

Amongst exhibits of technical work from schools in Great Britain must be mentioned those from the Allan Glen Institute, Glasgow; from the Technical School of University College, Nottingham; the Royal Albert Hall School of Wood Carving; the Manchester Technical School, and the Finsbury Technical College. These exhibits, together with some few others, show that technical teaching is at last beginning to receive some of the attention which it has so long needed in England.

The Belgian Government arranged a very extensive series of objects illustrative of the results of their new educational system. Infant Schools and Kinder-garten, Primary Schools, Technical Schools, and Training Colleges were fully represented. The methods of instruction in drawing were especially noteworthy for the results obtained. It is greatly to be hoped that the clerical reaction in Belgium may not lead to any material alteration in the most complete scheme of State-directed education which has yet been put forward.

Amongst special branches of education, which have been illustrated in this Exhibition, must be mentioned the instruction of the deaf and of the blind. Daily demonstrations of the oral system were given in the room arranged by the Ealing Society for the purpose by that Institution, by the Oral Association in Fitzroy-square, and by the Jews' Deaf and Dumb Home.

The lady principal of the Ealing College was constantly in attendance to explain the methods of teaching, and the afternoon demonstrations attracted a very large number of visitors. There can be but little doubt that the introduction of the oral system will be materially promoted by the widespread interest and admiration excited on all occasions in the very numerous body of persons who took the opportunity offered of seeing the process of teaching.

The teaching of the blind was illustrated by exhibits from the National Institution in Paris, the Naples Institution, the British and Foreign Blind Association, the York School, and others. Dr. Armitage, of the British and Foreign Association, gave occasional demonstrations, and a blind attendant showed the improved method of writing by the Braille system daily. A Kinder-garten class for blind children was held on one occasion by the British and Foreign School Society, and an admirable exhibition of drill and gymnastics was given in the arena of the Albert Hall, by the students of the Royal Normal College of Music for the Blind at Norwood.

Physical education was by no means neglected. In the Swedish gymnasium, installed by Mr. Thomas Nordenfeldt, Miss Bergmann and Captain Haasum gave demonstrations of Ling's system, with classes of boys and girls respectively, belonging to the schools of the School Board for London.

The boys of the Royal Hospital School at Greenwich, and of the Royal Military Asylum, Chelsea, gave several displays of their drill, extension exercises, and gymnastics.

The Anglo-German system of physical education was illustrated on a number of occasions by the German Gymnastic Society, under Herr von Schweizer; and by the Polytechnic Young Men's Christian Institution, under Colour-Sergeant Barber, in the arena of the Royal Albert Hall.

These displays attracted immense audiences, and there is already reason to believe that they have been the means of drawing the attention of many people to the desirability of physical training.

Before leaving this subject, the extraordinarily beautiful expositions of physical education for girls, given by Miss Chreiman, must be given. The gracefulness imparted to the pupils by the course of training devised by Miss Chreiman, was admitted by all who saw the demonstrations.

Undoubtedly the most important feature in connection with the Educational Section of the Exhibition, was the International Conference on Education, which took place in the rooms of the City and Guilds Institute, during the week commencing August 4th. The necessary arrangements were made and the programme

drawn up by a Committee consisting of Lord Reay (Chairman); the Ven. Archdeacon Emery; the Hon. E. Lyulph Stanley, M.P.; the Rev. T. Graham, D.D.; the Rev. T. W. Sharpe; the Rev. J. H. Rigg, D.D.; Mr. Philip Magnus; Mr. J. G. Fitch; Mr. B. St. John Ackers; and Mr. F. Storr, with Mr. R. Cowper (Secretary). Delegates were present from the following countries:—Austria-Hungary, Belgium, Brazil, Denmark, France, Germany (Baden and Saxe-Weimar), Italy, Japan, Netherlands, Norway, Russia, Spain, Switzerland, and the United States of America. The Conference met on August 4th, at 11 a.m., when Lord Carlingford presided, and the introductory address was delivered by Lord Reay.

Literature of the Exhibition.

The literature of the Health Exhibition, which was under the superintendence of Mr. Trendell, is grouped under four heads, viz.:—

Health in the Dwelling.
Health in Diet.
Health in Relation to Civic Life.
General Hygiene.

Three volumes being devoted to each of these sections, *i.e.*, a volume of handbooks, another of the reports of conferences bearing on that subject, the third being reports of lectures cognate to the section.

The handbooks, 28 in number, include amongst their authors such well known names as Sir Henry Acland, the head master of Eton, Sir Francis Bolton, Dr. Gamgee, Captain Shaw, and Dr. Duclaux, of Paris, Mrs. Gladstone kindly manifesting her interest in the Exhibition by writing a work on "Healthy Bedrooms and Nurseries."

The reports of the conferences, 14 in number, embrace an account of the proceedings of such important bodies as the Medical Society of London, National Health Society, Society of Medical Officers of Health, Sanitary Institute of Great Britain, and Parkes Museum of Hygiene, while among the non-medical societies appear the Society of Arts, the Social Science Association, the Central Chamber of Agriculture, and the Royal Meteorological Society.

Thirty-six lectures were delivered during the term of the Exhibition, mainly on subjects cognate to the handbooks, but a few of a special nature were admitted, such as "Anglo-Saxon Dress and Houses," "Physical Exercises for Girls," "Dairy Management," &c. In addition to these there are four special volumes forming the reports of the very important Educational Conferences, organised with such signal success by Lord Reay, to which I have just referred. Besides the volumes already mentioned—sixteen in number—there will be published four others, containing the general and special catalogues of the Exhibition, the jury awards, some very important papers setting forth the state of health of China, and giving interesting information as to the position of education in Chinese social and political life, which papers have been deemed worthy of a special place owing to light they throw on matters not easily investigated, and hitherto but little known in this country. The final or twentieth volume will contain the official report, statistical tables, and miscellaneous papers of general interest.

Let me now turn to one or two features of the Exhibition in which I feel a profound interest, which I trust you may share with me, and to which I look, and I hope that you will look, as promising to afford the most enduring and fruitful sequels.

Those features of the Exhibition which interested me most personally, partly, perhaps, because I had the honour of suggesting them, but also because they departed in some important respects from the ordinary routine of previous exhibitions, and because, I venture to think, they had a really pregnant and scientific value—were the sanitary and insanitary houses, the physiological laboratories, the meteorological pavilion, and library.

The Library.

The library sub-committee report with great satisfaction that the library has proved an unqualified success, and that it has attracted not only a large number of readers, but a considerable proportion of serious students.

Although no purchases of books have been made, upwards of 5,000 works are now included in the collection, of which over 3,000 relate to health subjects. The great majority are free gifts, a small proportion are on loan. They express a strong hope that a collection of books so useful as the nucleus for the formation of a special library will not be dispersed, but that the Executive Council will devise means to maintain the library on a permanent footing, as part of a memorial of this useful and successful national undertaking.

The library was altogether a novel feature in any exhibition of the kind, and its value was attested by the considerable number of serious

students who availed themselves of its extensive resources, many of them being University students, who used this unwonted opportunity in preparing for examinations. The advantages to be derived from retaining the library as a permanent institution would be great. I put before you a copy of the catalogue, made entirely by Mr. Carl Thimm. This catalogue is in itself a publication of no small interest, being the most complete catalogue of sanitary literature with which I am acquainted (although, of course, it cannot be said to be complete in even an approximate sense, but must only be regarded as a very valuable nucleus for a larger library), in which the hygienic literature of foreign nations, and especially their official hygienic literature, is very largely and well represented.

The Sanitary and Insanitary Houses.

Of the sanitary and insanitary houses a special handbook has been published, which will be preserved among the literature of the Exhibition, and which constitutes a small epitome of the ordinary defects of existing houses, and the simple means by which such defects may in future be avoided. I shall not enter into any description of these houses, for they are already well known to most of you, and may, I yet hope, be further studied on some future occasion. But I wish to draw your attention to the very important conferences on the sanitary arrangement of houses which were held by the Institute of British Architects in connection with this part of the Exhibition, and especially to that held in the last days of the Exhibition by the Guild of Plumbers. This I call your attention to because there is good reason to hope that out of this will spring an organisation, and I trust a legislation, which will, perhaps, do more towards the preservation of health and the saving of life than most of the much more pretentious forms of legislation which we must contemplate in the near future. The Exhibition will, in virtue of the organisation likely to follow from this conference, become the means of drawing together all those scattered forces which have for some time tended in the direction of a great improved regulation of the sanitary condition of our houses: a force, however, which, up to that moment, there seemed but little hope of being able so early and so practically to organise. I feel a peculiar interest in this subject, for I have now for several years, as chairman of the National Health Society, and in connection with the sanitary section of the British Medical Association, occupied myself with collecting the facts and figures which demonstrate the urgent necessity of improved legislation for the safeguarding of the sanitary construction of our houses, and the improved education and registration of those builders and plumbers to whom we entrust that construction. I read on this occasion at the opening of the congress a paper which I had prepared three years before, and which, in fact, I have in various forms presented to several professional and lay bodies, with the view of forming and gauging public opinion on the subject. I shall venture to put before you here now only the conclusions which I laid before this conference, which practically and in principle received their approval, and which will thus, I hope, have a earlier chance of finding their way into the statute book. They have the object of strengthening of our statute law as to drainage and plumbing. I desire to enlist the aid of the Society of Arts in bringing into legal operation, as one result of the International Exhibition, the proposals which will be found in the report of the conference, of substituting sanitary for insanitary houses.

First as regards drainage itself:—

1. Rural authorities should have the same powers as are now possessed by urban authorities. In the suburbs of towns, just outside the municipal boundaries, thousands of houses are springing up without any sanitary supervision whatever. The rural authority is, perhaps, unaware of the evil, or is, at any rate, careless about it, until the houses are erected; and their opportunity of making bye-laws which can control such houses is then lost.

2. It would be well that the requirements of the Model Bye-Laws as to New Buildings issued by the Local Government Board should be incorporated in a Building Act which should be forthwith passed, and be of general application throughout the country.

3. The plumbing and drainage of all buildings, public and private, should be executed in accordance with plans and specifications previously approved in writing by the local authority.

4. No drainage-work should be allowed to be covered or concealed in any way, until it had been examined and passed by the surveyor.

4A. The efficiency of all drains should be tested by the peppermint or some other test before they are passed; and it should be a rule that, wherever possible, drain-pipes should

be kept from view only by boarding which can be readily removed.

5. No new house should be allowed to be inhabited until it had been passed and certified by the surveyor, and a plan of the system of drainage should be appended in every case to the lease or other document for the letting of the house.

As regards the plumbers, I suggest that—

6. The names and addresses of all plumbers should be registered by the local authority, and no plumber should be able to carry on his trade until he had been so registered, and had received a license from the local authority.

7. Before the license is granted to him the plumber should attend personally at the office of the local authority, for examination as to his qualification as a plumber.

8. Such licenses should be renewed from year to year, and their continuance should depend upon the good behaviour of, and the return of the work done by, the licensee.

9. The names of all licensed plumbers should be publicly advertised once a year by the local authority.

The result of this conference will live. Before long, I think we may promise ourselves, we shall see, as one result of this Exhibition, an active movement set on foot, by which we shall henceforth be enabled to train skilled and educated workmen, and to ascertain by suitable tests their efficiency, and by which we shall be enabled to protect our artisans and ourselves from occupying houses which have been built with a total disregard or flagrant defiance of the first principles of sanitary construction, and of the conditions which we all know to be primarily essential to healthy occupation.

The Health Laboratories.

I pass to the laboratories. It did not at first, I think, appear evident to some of the members of our council how close was the connection between the work to be carried on in these laboratories and the public health. Happily, however, that feeling soon gave way to one of acquiesence in the proposition which I made for the establishment of these laboratories, and, since, a closer examination of the subject has, I think, convinced everyone that it is to establishments of research and of study, such as those over which Mr. Watson Cheyne and Professor Corfield, presided, that we must look for the most solid foundations for future progress, in solving the highest problems connected with the preservation of health : and that no part of the Exhibition fulfilled a higher purpose, and to none can we look with more assured hope in the future, than to these departments of the Exhibition. A description of the laboratories appears in the official catalogue, and I shall not occupy your time with any description of them.

At the Hygienic Laboratory, in its chemical and physical departments, the public were not merely given the opportunity of seeing hygienic analyses of various kinds going on, and of having them explained to them either by Professor Corfield or his assistants, individually or in the form of popular demonstrations—of which a considerable number were given, chiefly by the senior assistant, Mr. C. E. Cassall, during the time the Exhibition was open—but they also had the opportunity of seeing the ordinary working of such a laboratory, from the fact that Professor Corfield was able to utilise this laboratory for his students. A class of about forty teachers, selected by the Science and Art Department from schools in all parts of the country, attended a course of lectures given by him at the Normal School of Science, and at the same time worked in batches in the hygienic laboratory at the Health Exhibition, and thus the public were enabled to form an idea of what such a laboratory is in full working order; and, indeed, during the whole time that the Exhibition was open after the above-mentioned class had dispersed, there were pupils who worked in the laboratory.

In a complete hygienic laboratory there should be a separate part set aside for physical experiments relating to hygienic appliances ; but in this laboratory there was barely space for the chemical work to be carried on, and even the microscopical work could only be prosecuted to a limited extent, insomuch that the class of teachers went through their course of microscopy relating to hygiene in the physical laboratory at the Normal School, and the absence of physical appliances was replaced, as far as it could be, by demonstrations given by Professor Corfield at the sanitary and insanitary houses.

As regards the biological laboratory, it is sufficient for my purpose to-night to remind you that in it, Mr. Cheyne, the worthy pupil of Sir Joseph Lister, who acted as chairman of the laboratory sub-committee, showed by practical working, and by collections such as had never before been seen in this country with the same completeness, the refined methods of research and of teaching by which we are enabled to study the life, history, and the habits,

the development, and the means of arresting the development, of those minute organisms which modern science has shown to be prime factors in the causation of a great proportion of the most fatal diseases which afflict our flocks and herds, which decimate mankind, and which attack those plants and animals which constitute the staple of our food supplies. Mr. Cheyne's demonstrations were eagerly followed by health students from all parts of the kingdom. A certain number of tables were set apart for study and research, and these were fully occupied from the first to the last days that the Exhibition was open. In Dr. Corfield's laboratory was collected the apparatus for that kind of instruction in the chemical and physical examination of soil, air, water, food, clothing, and materials of house construction, which are essential elements in the education of that great army of medical officers of health who are appointed now under existing Act of Parliament to watch over the health interest of the community. It is very well known, however, that a large majority of those gentlemen have not this necessary instruction, and that at the present moment there does not exist in this country any adequate means for giving such instruction. There are in England 1,102 medical officers of health, and 996 inspectors of nuisances, all of whom are expected to get their information, and to acquire the technical knowledge of which they stand daily in need, as best they can; and it is well known that a large proportion of them are very imperfectly equipped with the necessary knowledge, and, indeed, can hardly be said to possess even the rudiments of systematic technical education in subjects in which they are presumed to be experts on, which they are called upon to decide in matters largely affecting the pockets of the community, and intimately concerning its health. In order to illustrate the importance of the establishment in this country on a permanent footing of such laboratories as those which are shown in temporary working at the Exhibition, I shall ask leave now to refer you to an exhibit which was made in the French Court, illustrating the work done in a similar laboratory by M. Pasteur to that of which I am now advocating the permanent establishment, as the best possible sequel of this great Exhibition.

M. Pasteur is the scientific director of the Ecole Normale Superieure in Paris, a school especially designed to supply professors in literature and science to the *lyceés* or higher schools of France. He is not, however, called upon to undertake teaching, but is expected to devote all his time to his researches. In a word, in consideration of the considerable national services which he has rendered, an exceptional position has been accorded to him. He receives a professorial salary of £400 a year. M. Pasteur is also the head of l'Ecole des Hautes Etudes, of which Mr. Chamberlain is the sub-director. In this laboratory he receives some pupils. He possesses further a laboratory at the Ecole Normale, where M. Roux is his coadjutor, and where are admitted some students, who are generally persons already known for their studies. He has entire freedom of the choice of students of the laboratory Ecole des Hautes Etudes, as well as those of persons who work in his private laboratory at the Ecole Normale. About £800 a year are allowed for this laboratory by the Minister of Public Instruction and for the last few years, 30,000 francs from the Minister of Commerce and Agriculture. These grants are renewed yearly.

The principal researches of M. Pasteur have related to:—

1. *Wine*, in which he demonstrated that in order to avoid the transformation of alcohol into acid, it is necessary to destroy the germs remaining in wines which are poor in alcohol, by heating them up to 55°-60° Centigrade. He has also studied the action of oxygen and light on wine, and has demonstrated that it is to this action, *i.e.*, to the oxidation of the materials of wine, that we are to attribute the development of the bouquet of wine, *i e.*, the flavour which it acquires with age. In order that this may yield a product appreciated by amateurs, it is necessary that it should proceed slowly. He has further demonstrated that the ferment of wine exists on the surface of the grape when it has ripened. He has demonstrated the useful and precise indications which the areometer furnishes, in order to appreciate during fermentation the state of the *mout* of the grape.

2. *Beer*.—After having demonstrated that brewers employ, generally, a ferment containing, among others, injurious germs, M. Pasteur indicates the following means for obtaining a pure ferment. A small quantity of pure yeast is prepared according to the exact rules of the laboratory. This is introduced into a large copper pan, three-quarters filled with the wort of beer, which has been first carried to the boiling point, and then cooled before the introduction of the yeast. This vessel only

communicates with the external air by a long tube of copper, many times bent in such a way as to permit the gases to escape without external germs being able to enter. When the wort has been developed, it is drawn off by a tap placed in the lower part of the apparatus, and which is previously purified with the flame of a spirit lamp. The wort of the beer is put to ferment in a large white-metal vat, resting on a plank, and closed by a movable cover, this movable lid dropping into a groove which is kept full of water. As the wort arrives in a boiling state in this vessel, it destroys any germs which may exist there. When it is cooled, and the cooling may be rapidly aided by the use of external cooling water, the yeast is introduced through an opening in the lid. The aëration of the fluid is obtained by two tubes curved downwards, by one of which carbonic acid escapes, and by the other the air enters, after being previously filtered through a layer of cotton wool rolled round a cylindrical cage on metal wires which cap the extremity by which the air enters. This apparatus, like the foregoing one, reproduces exactly the conditions which are found to be necessary in the laboratory to prevent the introduction of external germs. The aëration by these two tubes is sufficient, for the carbonic oxide being heavier than air, they are placed in such a way as to form a syphon; moreover, during the fermentation, the wort is certainly kept in movement by the ebullition of the gas which escapes, so that the aëration, although less active than in some of the technical apparatus previously in use by brewers, is more than sufficient. By employing this procedure, secondary fermentations are no longer to be feared, and the spoiling of beer by secondary fermentation is almost entirely put an end to.

3. A third and profoundly interesting series of researches, which have had a great influence on agriculture carried on by M. Pasteur, are those relating to *charbon*—the malignant pustule or black quarter of cattle and sheep. M. Pasteur has demonstrated that animals of the ovine and bovine species may be prevented from contracting the disease of *charbon* by inoculating them with attenuated germs, obtained by artificial cultivation of the specific minute organism which is ascertained to exist in the case of *charbon*, and to be the efficient cause of the disease. This attenuated preventative material for inoculation is obtained by the aid of what are known as cultivations of the germs made in special liquids. After the first inoculation with the highly attenuated virus, Pasteur has shown that the second inoculation may be made with a product of medium virulence, and that the animals thus twice vaccinated were unsusceptible of contracting the disease. Pasteur has further demonstrated that the bacteria of *charbon* is capable of retaining its vitality for several years in the earth, and that, when brought to the surface by earth-worms, it is capable of infecting the animals which eat the grass polluted by its contact, especially if the grasses or plants so eaten be hard, and such as to cause abrasions in the mouth and digestive tube.

4. *Silkworm Disease.*—M. Pasteur, after having assured himself that normally, and in good health, silkworms never contain, at any moment of their life, the bacteria or corpuscles seen for the first time by Guérin Menneville, demonstrated that the eggs of the worms, even when only slightly attacked, contained a great number of these corpuscles or bacteria, which developed in considerable quantities when the animal underwent its metamorphoses, and finally destroyed it; since its droppings polluted the leaves of the mulberry on which the silkworm feeds; and as healthy animals thus devoured them, and contracted the same disease, a single infected silkworm was capable of destroying a whole school of worms, and preventing the subsequent cultures from being developed.

M. Pasteur then laid down the rule that, in order to avoid the silkworm disease, it was necessary to choose with extreme care the animals which were to be employed for breeding. With this view he devised the following procedure. When the female has laid its eggs it is at once destroyed. If a single corpuscle is found in its tissues, when crushed in water, the eggs are immediately burned. In the same way the several eggs of each hatching are carefully examined. If no corpuscles are discovered, the white brood is preserved for culture; if any are found, the whole are immediately destroyed. Since that time the silkworm breeders have followed the rules of M. Pasteur. The implements for the purpose of recognising the diseased worms consist of a microscope, two objectives, one with low power and one with high power, magnifying about 400 times, and a small porcelain mortar for crushing the tissues of the worm or its eggs, some glass slides, and a flask of distilled water. By this application of scientific research to the silkworm industry, the silkworm disease has been almost wholly put an end to. Nearly all the silkworm growers, whether masters or servants,

have learnt, by the aid of a very cheap little handbook, prepared by M. Pasteur, to recognise diseased worms or eggs from healthy eggs or worms, and thus a great industry, which was threatened with extinction, has been saved from the fate which threatened it.

5. *Fowl Cholera.*—After having demonstrated that this affection is caused by a micrococcus, M. Pasteur showed that if this micrococcus is cultivated in the manner which he indicates, and the micro-organism then obtained inoculated in a fowl, the fowls so vaccinated become proof against fowl cholera, even when they are placed in the midst of other infected fowls. These researches have a special and suggestive scientific interest, for he has shown that if you filter through plaster the liquid taken from one of the external foci of the disease in a fowl affected with fowl cholera, the filtered liquid thus inoculated will not give a healthy fowl the specific disease, but render it somnolent and inert for some hours, so that it may be concluded that the micro-organism secretes a material to which must be attributed the lesions which are observed in fowls suffering from fowl cholera.

Some idea may be obtained of the commercial value of the work done by M. Pasteur in his laboratories from the following facts and figures, which I have on good authority:—In three departments of the centre of France, after the silkworm disease had attacked the factories, the product yielded a value of less than one million five hundred thousand francs. Since the regulations laid down by Pasteur have been applied, the average value per annum, calculated on five years, in those departments has risen to more than 22 millions of francs.

As to wine, there was a known loss of wine to the extent of one million seven hundred thousand francs in four departments. Since heating on Pasteur's method has been applied, there has been saved of this loss at least one million five hundred thousand francs; the difference of two hundred thousand francs being alleged to be due to the carelessness or ignorance of small proprietors, who are unwilling to heat their wine. As there are in France about 45 departments that make wine, the saving may thus approximately be estimated. I should add that there are 12 departments that make silk.

In respect to anthrax, the following was the official statement indicating the ravages made by this disease in France and foreign countries, and the reduction or mortality effected by these inoculations:—

	Sheep.	Oxen.	Horses.
1881.			
France	62,050	5,977	142
Foreign countries	12,500	1,254	100
Total	74,550	7,231	242
1882.			
France..............	270,040	35,654	1,825
Foreign countries	36,830	6,169	200
Total	306,870	41,823	2,025
1883.			
France..............	268,205	26,453	371
Other countries	84,825	5,777	975
Total	353,330	32,230	1,346

The average mortality reduced by these inoculations in the proportion of 10 to 1 for sheep, and 15 to 1 for oxen, cows, and horses.*

Meteorological Laboratory.

The corresponding exhibit was that of the meteorological laboratory by M. Miquel, in corresponding which I hope to see a permanent meteorological station established as a sequel to the Exhibition. The work of M. Miquel has has been summarised, in the following words by Dr. Vivian Poore—The observatory for Mount-Souris was established, in 1871, by the influence of M. Dumas, who was then president of the Municipal Council of the city of Paris. In 1873, M. Marié Davy was appointed director of the observatory by M. Thiers. The work of the observatory is as follows:—

1. Meteorology proper, and its application to agriculture and hygiene. This department is under the control of M. Leon Descroix.

2. Chemical analysis of the air and rain, under the control of M. Albert Lévy.

3. The microscopic study of the organic matters held in suspension in the air and rain. This is under the control of M. P. Miquel.

In 1876, the municipality decided to have the above meteorological observations, in their relation to hygiene, made in different parts of the city. The chemical analyses and microscopical examinations are made—

* In the last thirty years there has been an increase of life-duration of from 39·9 to 41·9 years, an addition of 5 per cent. human duration of life. The annual economy of life, on the least favourable calculation, during the last five years, has been equal to a saving of 36,000 lives per annum. The money saving on the last five years has been calculated, on good basis, by Capt. Galton, to be in London alone nearly half a million of money per annum.

1. On drinking waters.

2. On the waters infiltrating the soil.

3. On the emanations from the soil and sewers.

4. On the air of different localities estimations are made. A. (air), ozone, carbonic acid, ammonia, organic nitrogen; and similar analyses are made of the soil water, &c. Every year the *Annuaire de Montsouris* is published, a work full of information, and which is now in its 13th volume.

The laboratory of Mr. Cheyne, at the International Health Exhibition, was largely fitted up by the aid of Dr. Koch, and of Dr. Koch's laboratory at Berlin. Mr. Cheyne has furnished me with the following outline :—

Dr Koch's laboratory is subsidised by the Government. It consists of director, library, biological department under Koch and several assistants, and a chemical department. All expenses of investigation are paid. Koch's salary is only £300. Other salaries I do not know. When appointed, Koch first set to work to improve methods of cultivating and studying bacteria, and to devise new methods, and the result has been a precision and simplicity in this sort of work quite beyond all expectation. His further researches have been devoted to the study of the cause of disease in man and how to prevent it. Either by himself, or under his direction, the causes and means of prevention of tuberculosis, consumption, erysipelas, osteomyelitis, and glanders, have been absolutely demonstrated; while a large amount of work has been done in respect to the causation and prevention of typhoid fever, cholera, diphtheria, and other affections. His researches on disinfectants, and the best mode of disinfection, are classical, and are still being carried on. This work is being rapidly extended to other diseases, while important researches are going on relating to water, air, and soil.

The Anthropometric Laboratory at the Health Exhibition was designed by Mr. Galton, to show the feasibility of performing, at a small cost, an extended series of measurements of the human faculties, and of testing the demand that there might at present be for having such measurements made. The ulterior object he had in view was to familiarise the public with the facility and need of periodically recording facts which test the progress of individual growth and development, whether it is proceeding normally or otherwise; and if it should be abnormal, to call attention to the existence of hurtful influences, and to demand inquiry into their nature, and whether they may not be removable. The experience of the laboratory showed emphatically, first, that about seventeen different measurements of each person, including height, weight, strength, breathing capacity, eyesight, judgment of eye, hearing powers, &c., could be accurately performed at a cost of less than £3, by means of a well-organized method of work; secondly, it showed that the public greatly valued the opportunity of having themselves measured and appraised in so minute a manner, inasmuch as the door of the laboratory was besieged all day long by a crowd of applicants for admission, far more numerous than could be accommodated in its small area, 36 feet long by 6 feet wide. As it was, measurements were made of between nine and ten thousand persons, yielding data that are now being discussed, and which have considerable statistical value. The methods and appliances used and suggested by the experience of this laboratory have been very recently described by Mr. Galton at the Anthropological Institute, which will, doubtless, appear in due course in this *Journal*. It is therefore not necessary here to go into details. It may be taken as established that there need not be the slightest difficulty in periodically measuring with much completeness and keeping a register of the development of every boy and girl in large schools, at the cost of a very few pence per head per annum, on the supposition that the process was methodically conducted by a paid expert, with the willing and gratuitous assistance of the masters and attendants. The power of a system of periodical measurements and tabulated returns upon the well or ill-being of the growing portion of our race is of unquestionable value, and it would seem that common-sense considerations must ensure its being ultimately called into action. Now that there are signs of much awakening to the importance of such records, a central institution becomes especially desirable, where the best patterns of instruments should be kept, where instruction in their use might be obtained, where the methods of tabulation, and of quickly getting useful results out of the data, might be learnt, and where the fullest information of all kinds on anthropometry would be stored. It must not for a moment be supposed that anthropometry is a simple and thoroughly understood art. On the contrary, it continually grows, new methods being discovered from time to time of measuring faculties that had before escaped measurement. There can be little doubt that the progress of the useful art of

knowing oneself all round, and of knowing others accurately, of reducing what has hitherto been too much a matter of estimate to quantitative measurement, would be very largely aided by the establishment of an anthropometric laboratory in a national hygienic institution.

That which I look forward to, then, as the best possible sequel to this Exhibition, is the establishment of these laboratories, so vastly important to the prevention of disease and the maintenance of our population in health, and of the library on a permanent footing and under suitable direction. The whole subject is one on which I can only venture to express, thus far, my individual opinion, although I have the satisfaction of knowing that the views which I have thus put forward have met with considerable approval among many of my colleagues, to whom I have submitted them *in limine* for future consideration by the Executive Council, who may possibly approve of them, and in that case may feel it their duty to submit them to his Royal Highness the President, with whom will rest the ultimate decision as to the disposal of any parts of the surplus. The rumour that such a project was about to be submitted to the Conncil, has awakened the liveliest interest and satisfaction amongst the authorities of the leading sanitary associations in this country, and I am glad to know that the authorities of the Parkes Museum, of the Sanitary Institute, of the Social Science Association, of the Society of Medical Officers of Health, and of the National Health Society, have each, on their own individual motion, taken the opportunity of expressing, by resolutions and memorials, their strong sense of the great national value which they consider would attach to the accomplishment of this design. Should this proposition prove acceptable to the authorities, there is no doubt that the opinion of the great body of persons interested in the sanitary progress of this country, thus early expressed by the official representatives of every form of sanitary progress, would declare itself strongly in favour of an institution from which considerable results might be anticipated in the furtherance of health education, and of our knowledge of all that relates to the prevention of disease. It is further hoped that an Institute of Public Health, founded on this basis, might prove a home and centre with which these numerous voluntary organisations now working for the public health might connect themselves, by some well co-ordinated and accepted plan; that it might be a centre where their members would be able to meet; where libraries, class-rooms, and meeting-rooms might be made to serve a valuable purpose in bringing these various societies into closer relation. There is reason to hope that many of the great scientific associations which now foster the progress of science by grants to individual workers, would heartily welcome the establishment in this country of what it so greatly stands in need—a place of higher education and research in sanitary science, such, as I have already pointed out, as have been recently created in France and Germany. England has been first in sanitation; it is here that have been solved—so far as they have as yet been solved—many of the greatest problems of sanitary science; but we must acknowledge that, during the last decade, each of these countries has made progress in the higher departments of sanitary education and sanitary research, in which we can hardly be said to have held an equal place. This reproach we may now find the means of wiping away, and I earnestly trust that this may prove to be a sequel of the International Health Exhibition, than which no higher memorial could have been hoped for or expected.

The Lesson of the Exhibition as to Open-air Recreation and the Electric Lighting of Public Parks.

Let me conclude by reference to another aspect of the teaching of the Exhibition, less scientific, but yet of peculiar public importance. It was often said by the public scorner—a person from whose judgments and criticisms we have commonly much to learn—when walking through the crowded course of the Exhibition devoted to food, and all that concerns the construction and decoration of the dwelling:—"This is a Health Exhibition—Where is the health?" and the popular answer was, "Outside in the gardens." That answer also I accept. I think you will agree with me that the practical demonstration which this Exhibition afforded of the eagerness of the English people to resort to healthful means of outdoor amusement was in itself a valuable result, and an important experience. The gardens, illuminated by the electric light and enlivened by music, were undoubtedly a great attraction to the Exhibition, and I would be quite willing to agree with anyone who might say that they were the greatest attraction. Allow me to add that I look upon this not merely as a means, but itself an end. It is no small thing to have

acquired the conviction that our open spaces may be, and should be, much more largely devoted to the open-air recreation of the people than they are at the present moment. I say this now, without any intention of entering upon that large question, but with the specific desire to repeat (for it is only by repeating often that one can gain access to the minds of the majority who are all powerful in such questions) that it appears to me to be no small disgrace to this great metropolis that, in the very centre of its crowded districts, within an arrow's flight of the houses probably of most of us who are here, there lie great open spaces, such as Hyde-park (but what I say refers also to Victoria-park) which at night are dreary desolate areas of darkness, which are unlighted, which are dangerous to cross, which are unused in the evenings for any wholesome or moral purpose, which are often scenes for the display of some of the worst vices incidental to the lowest dregs of the population of the great City. Why should we not learn from the success of the music and the lighting of the gardens of the Health Exhibition, that our great parks should all be lighted by the electric light at night, and that throughout the spring and summer months the military bands should play there, and should make those places, which are now not only useless but scandals to the metropolis, the sites of healthful and innocent recreation? I have inquired from a good source what would be the cost of lighting Hyde-park by the electric light; and I am not speaking without data when I say that I believe that Hyde-park could be adequately lighted with the electric light, so that it might add to the resources of health and enjoyment for the teeming population surrounding it, at an annual expenditure of about £5,000. I do not know what impression this will make upon you. I confess that to me such an expenditure seems trifling in consideration of the sum of human happiness and enjoyment, and, I may add, also of health, which such a devotion of municipal or public money would afford to the people of this city. Nor is it likely that the example once set, it would end here. Our Eastern population have a right to the enjoyment of their parks in the evenings that could be conceded to the West. This lesson also, then, the Exhibition seems to me to teach, and how greatly we might all rejoice if it should ultimately prove, that the lighting by electric light of our public parks, and the introduction of music as a part to enliven and attract the people, and to add to the success of the innocent re-recreation, the health and the happiness of our working population, should form also one of the possible sequels of this Exhibition.

DISCUSSION.

Sir Frederick Abel, D.C.L., C.B., F.R.S., said that as he had devoted so much of his address last week to the Health Exhibition, he could not venture to detain the meeting with many words now. He was glad to find that the views he then expressed coincided in almost every respect with those expressed in the paper. Mr. Hart had touched on almost every important point connected with the Exhibition, and wherever he had left any blank, he (Sir F. Abel) believed that might be supplied from his own imperfect sketch. He might refer to Mr. Hart's eloquent reference to the future of the electric light in rescuing some of our dark places from their present worse than useless condition, in order to point out that the great achievements of the electric light at the Exhibition had been dealt with in last week's address. There was no doubt that great progress had been shown in this department, and it might be expected that the illumination of public places, as well as of large buildings and small dwellings, would be facilitated thereby. As a member of the Jury Commission, he might be allowed to bear testimony to the great labour bestowed by the members of the jury, many of them most eminent men, on the somewhat thankless work of carefully examining the merits of the various exhibits. Some of the reports, which were necessarily of a more or less confidential character, were most interesting. It was his duty to assist in examining these reports, and in weighing as carefully and judiciously as possible the conclusions arrived at by the jurors; and he could bear hearty testimony to the success of their labours, and to the general justice with which the rewards were meted out by the jurors. With regard to the laboratories, the portion of the Exhibition in which he naturally took the most lively interest, he most heartily supported the views Mr. Hart had expressed regarding the important work there achieved. They had not merely opened the eyes of those of the public who visited them to the importance of the application of science to daily life, but they had also opened the minds of those who had already devoted themselves to such researches, to the importance especially of those particular kinds of research which were provided for in the physiological laboratory. Mr. Hart had given a few very striking instances of the glorious results achieved by M. Pasteur, and might have referred to similar work, equal almost in importance, accomplished by Koch and others; and, no doubt, on reading the paper, convincing proof would be found, that in every direction connected with our

national health and prosperity such laboratories were absolutely essential. Such laboratories had been established abroad, where, in consequence perhaps of individual liberty not being so jealously guarded, it was more easy to do this, but he was perfectly sure that the Health Exhibition would mark a point of departure in this country with respect to the application of scientific research to daily life. If they could succeed in carrying out the scheme on which amongst themselves there was a perfect consensus of opinion, viz., that such financial results as might have accrued from the Exhibition should be devoted to the establishment of institutions of a national character in which these branches of research should be carried on by men able in every respect to conduct them, great good would result. There were such men here, pupils of Pasteur, Koch, Lister, and others, who were only awaiting the opportunity to do what was being done abroad, and he was quite sure that if the opportunity were offered, the results achieved would be equally important.

Mr. WILLIAM BOTLY said he had taken great interest in exhibitions from the very first, having been associated with the Bishop of Salisbury, and Mr. Fawcett, then Mayor of Salisbury, on the local committee formed to assist in getting up the Great Exhibition of 1851; he had also been a guarantor to the Exhibition of 1862, and assisted other members of the Society in aiding in the French Exhibition, and in sending over the English artisans whose reports were so valuable and interesting. He was glad to hear the credit given to the Social Science Association for having taken the lead in Health Exhibitions which was its due, and he saw no reason to doubt that as the first Great Exhibition of 1851 had marked a new era for the manufacturing and trading classes of this country, so this Health Exhibition would produce results of at least equal importance with regard to the national health. Every one must have been struck with the suggestion at the close of the paper, that the open spaces around the metropolis should be utilised as places of public amusement, and he hoped the idea would not be lost sight of.

Mr. E. C. ROBINS spoke in high terms of the paper they had had the pleasure of listening to, which would form a most useful memorial of the Exhibition. Having had to do with some of the arrangements, he must express his gratitude to Mr. Hart for specially mentioning matters in which he had taken a particular interest—for example, sanitary and insanitary houses. He was glad to find that the public took a great deal of interest in these houses, because they afforded familiar illustrations which every one could apply for themselves, and the only thing to be regretted was that they were finished so late in the year. He hoped, amongst the many good things promised as the result of the Exhibition, that they might be left standing, as a permanent proof that the Health Exhibition really deserved its name. He also hoped that Old London would not be taken away, seeing the great interest which attached to it from an architectural as well as an archæological point of view. The publications were also of great importance, and as hon. secretary to the Conference of the Royal Institute of British Architects, he was glad to hear the papers and discussions then so highly spoken of, as it would, perhaps, tend to a larger circulation of these reports. They were certainly very voluminous, and some persons might be almost afraid of beginning them; but the whole need not be mastered by every one, and portions might easily be picked out which would be found remarkably interesting. He hoped the results of the Exhibition would be lasting, and that in future the English public and Legislature would not be so backward as they had hitherto been in adopting the measures necessary for the protection of the public health.

Dr. ALFRED CARPENTER said he was not quite sure whether, as a doctor, he ought to be thankful for the Health Exhibition, for he understood from many of his medical brethren that they had not been at at all busy lately, though whether the Exhibition and various conferences in connection with it had already begun to show their influence on the health of the people remained to be seen. It might be that the beautiful weather which had helped to make the Exhibition a success, had also had an effect on the health of the public generally; but he was quite sure that the Exhibition had tended to popularise knowledge amongst the people, and to get rid of some of that crass ignorance which was so prevalent, especially among the middle and upper lower classes, as to what was or was not injurious to health. Some of Mr. Hart's observations came home to him quite closely, his reference to the plumbers, for instance; for it happened that many years ago he was instrumental in bringing before the public in his neighbourhood the sanitary defects arising from imperfect plumbers' work, and after pressing this point on the local authority, he had the honour of being publicly burnt in effigy as the reward of his labours in the public interest. However, this had the effect of directing the attention of the authorities still more to the points he had raised; and now he was glad to see that the plumbers themselves recognised the necessity for those regulations which he had advocated ten or twelve years ago. He was quite certain, from his knowledge of the way in which the health of the public had been sacrificed by insufficient plumbing, that the mere fact of plumbers themselves insisting on proper work and education would tend very materially to assist in raising the public health. The crowning portion of the paper, however, was the reference to the important work in connection with the biological and chemical laboratories, and the necessity that those laboratories should be continued, and become a lasting memorial of the Health Exhibition. They would bring about results which

at present they could hardly realise. That these results would be brought about in the future he felt confident. They had only to look at the enormous amount of preventible disease which existed, to be aware that when that was removed there would be a complete alteration; and it was now evident that prevention was becoming much more important than cure, and that was, after all, the foundation on which the Health Exhibition would rest.

The CHAIRMAN then invited the meeting to pass a vote of thanks to Mr. Hart for the interesting paper he had read, and for the able manner in which he had concisely brought forward the principal features of the Exhibition. He gathered from the remarks which had been made that there were certainly some of those features which had received very general approval. The Exhibition differed, in one respect, from any previous one held in this country, inasmuch as instead of confining it to articles which were deserving of merit, and competed for rewards, the Executive Council thought it well, in the interest of health, that the bad as well as the good should be included; and that they should bring prominently before the visitors and the trades concerned the defects which had been found by constant examination to exist in the sanitary arrangements of houses, and the workmanship connected with them. They, therefore, took the somewhat bold step of exhibiting things which were to be condemned as well as those which were to be rewarded. The comparison of such things, whether in the sanitary and insanitary houses, or in the numerous collections of defective plumbing, actual specimens of defective work, not old, but modern work cut out of new houses, and of defective drainage, could not have been without their effect on the minds of the workmen and the builder, as well as to put those who were to occupy the houses on their guard against permitting or overlooking such defects. Another point on which there seemed to be a general concurrence of opinion was that the financial results of the Exhibition, whatever they might be, should, if possible, be consolidated into some one principal object, rather than be frittered away in donations, or distributed to numerous objects, none of which, perhaps, could be by such means effectively established and made permanent. There was no doubt that great benefit to the country, in every part of its great interests, whether in manufactures, in the health of the public, of its flocks and herds, and even in the health of the food-producing plants, would result from these careful and minute examinations which had been carried out in other countries, by the methods which had been shown in operation in the laboratories in the Exhibition. He entertained no doubt that if such laboratories could be established, English experimentalists and chemists would be found as patient and successful in their researches as Pasteur or any other of the able men who had been referred to. It was by such researches that health must be sought, in the dwelling, in the diet, and in civil life, the three great objects which the Exhibition was intended to promote. This would be, after all, only carrying out the idea long ago promulgated by Sir Francis Bacon, who advocated the reduction of every question to the crucial test of actual experiment.

The vote of thanks having been carried unanimously,

Mr. ERNEST HART, in thanking the meeting for its kind expression of approval, said it had been a source of very great satisfaction to him to find that, in that assembly, as everywhere else where this question of the perpetuation of the Exhibition by the devotion of the surplus to the objects to which he had referred, had been adverted to, had been received with favour. He would only detain the meeting to say one thing more. He had referred especially to the researches of foreign observers, because he felt, in the present state of things in England, it might be invidious to select the work of any particular English investigator for comment. He had referred, therefore, to Pasteur and Koch; but it would not be right to forget the great work done by Englishmen, by Sir Joseph Lister, for instance, whose researches on the question of the multiplication of germs had revolutionised the whole practice of surgery throughout the world. And Mr. Cheyne had himself made a series of observations of most remarkable value as to the prevention of consumption, by following out researches of a similar kind. Again, in the intervals of his great scientific and practical work, Sir Joseph Lister had proved that the whole question of the souring of milk depended on the *bacterium lactis*, and that the butyric ferment was due to another kind of bacteria. The milk industry opened up a great field for investigations of this class; it was found that every variety of cheese was due to the influence of a particular kind of minute vegetable organism, which by its mode of maturation gave to each cheese its particular flavour and quality; so much so that one kind of cheese could be made only in one cellar, and another kind in a cellar perhaps 300 yards off, and in none of the intervening cellars could the same kind be made. The last time M. Pasteur was in England he went to a dairy, and he told him that his greatest desire would be, if he had three years to spare, to spend them in the laboratory of a dairy, working out the relation of germs to the milk and cheese industry.

Miscellaneous.

A NEW PROCESS OF PHOTOGRAPHIC PRINTING.

The idea of coating paper for photographic printing with a gelatino-bromide of silver followed obviously enough on the successful employment of the same

compound for the production of negatives, and many attempts have been made to produce, in this manner, a paper which might give results equal to those of the process which is always known as silver printing, and, at the same time, be so sensitive to light as to allow the image to be impressed on it in a few seconds, instead of requiring an exposure often of hours. The most successful experimenter in this direction was Mr. Morgan, of Greenwich, who produced a paper fulfilling the latter condition entirely, but giving pictures which certainly will not stand comparison with ordinary silver prints. For enlargements, however, Morgan's paper has come largely into use, and a considerable business appears now to be carried on in this department of photographic work. The chief objection to the paper is its cold grey, or even greenish, tone, and this appears the principal reason why pictures on it have not secured the favour of a public educated to a liking for the rich purple and chocolate hues of ordinary photographs. The enlargements are generally a good deal worked up by hand, and when carefully finished form no bad imitation of a crayon drawing. The difficulty of procuring warmth of tone and consequent brilliancy in the picture seems now to have been overcome in a new material which Messrs. Marion, the photographic dealers of Soho-square, have produced, and are about to supply commercially. Messrs. Marion propose to work the process in secret, believing that a safer method of proceeding than patenting it; and consequently the invention is of less interest to the scientific photographer than it would be if the manner of production as well as the results were revealed; but probably the effect on the photographic industry will be much the same. The paper is obviously coated with a gelatine emulsion of some sort, and in all probability rival experimenters will, before long, find out its precise nature. As regards the results producible by its means, their value does not seem to admit of much doubt. No industrial process can properly be termed successful until it has stood the test of regular commercial work; but it is, at all events, safe to say that no improvement of such promise has been introduced into photography since the advent of gelatine plates. In Messrs. Marion's studio, on Saturday last, the writer saw produced three prints, which nobody could tell were not ordinary silver prints, produced with exposures of two, three, and four seconds, and he afterwards, at home, at 4 o'clock in the afternoon, with an exposure of fifteen seconds, produced, on a first trial, almost equally good results.

Now, if material of similar quality can be supplied commercially, and at a reasonable price, it is easy to see what a valuable power the portrait photographer has given to him. The whole process of producing a couple of dozen prints need not take an hour. Allowing time for washing, mounting, and finishing, an energetic man can, if required, supply his customers with their likenesses the next day after the portraits are taken. In these dark, short, winter days it may be weeks before a photographer gets light enough to print a batch of pictures; but by Messrs. Marion's invention the whole thing can be done by gaslight.

The process of working the paper is quite simple. As may be supposed, the image has to be "developed"—that is, no visible image is produced by the exposure to light. Consequently, the exposure has to be estimated, as it has in taking a portrait or a view. The development is effected in very much the same way as if an ordinary gelatine plate were under treatment, the developer being a weak solution of ferrous oxalate. After development the image is of rich purple; but as this would change in the final, or "fixing," bath, it is necessary to "tone" the picture, as is done with an ordinary silver print, in a solution containing gold. After this the picture is "fixed" in the usual manner. Considerably variety of tone can be produced, the tints ranging from a warm red brown to a purple, or even black.

The objections to the process are that it requires rather more skill than the old system. It has to be carried out in greater darkness, and with greater precaution. Nor are the results quite so bright and good as the best silver printing. It would, however require an expert to tell the difference, and certainly no purchaser would be likely to complain if he were supplied with a batch of prints on the new paper. As regards permanence, only time can answer that question; but there seems no reason why it should be less permanent than the old, which, unfortunately, has in this particular not much to boast of. Having regard to all considerations, it may be expected that the albumenised paper will still hold its own for the finest work, and for work in summer, when the light is bright and abundant; but the new paper will, in all probability, come largely into use for winter work, and it ought to be used by all portrait photographers for sending out "proofs" at once of their portraits.—*The Times.*

INDIAN COTTON.

In the recently published review of the trade of British India with foreign countries, for the year ending March 31, 1883, it is stated that this important item in the list of Indian exports has steadily increased in volume since 1878-9. The quantity exported in 1883—viz., 6,168,278 cwt., of the value of £16,049,017, was far in excess of the export of any of the last 10 years, during which period the largest export was 5,627,453 cwt., valued at £14,935,960, in 1882; closely approached, in 1875 with 5,600,086 cwt., valued at £15,257,342; while the smallest export was 2,966,060 cwt., valued at £7,913,046, in 1879. The increase last year over 1882 was more than $9\frac{1}{2}$ per cent. in quantity, and under $7\frac{1}{2}$ per cent. in value. The quantity exported has increased, in 10 years, 37 per cent. In 1883, a considerable stimulus was

given to the trade by the disturbances in Egypt, which interrupted supplies from that country, and a much greater impetus was given by the small dimensions of the American cotton crop. The increasing demand for Indian cotton on the European continent, where the mills look for the cheapest article, gives a more permanent stimulus to this trade. More than half the Indian cotton exported to England is re-shipped to the Continent, and there is also a considerable direct trade between Bombay and Austria, Italy, France, Belgium, Germany and Spain. The quantity exported last year direct to European countries, except England, was 2,891,444 cwt., which exceeds the export to England by 26,379 cwt. The Continent is thus seen to be the great outlet for Indian cotton. The export to China was 368,556 cwt., to a large extent the produce of Bengal. The acreage under cotton largely increased during the year 1881-2. Thus in Berar there were 2,189,688 acres under this crop in 1881-2, compared with 1,755,946 acres in 1880-1; and, in the Nizam's dominions, 1,009,766 acres, against 811,436 acres, with a good out-turn per acre in both cases In the Central Provinces, however, the yield is greatly diminished, and the area is said to have fallen from 682,962 acres to 626,716 acres. In the Punjab, the area has increased from 761,729 acres to 918,265 acres. In the North-Western Provinces, and Oudh, it has risen rofm 1,419,042 acres to 1,637,364 acres. In Bombay, including the native States in that Presidency, the area increased from 4,193,594 acres to 4,811,146 acres; and in Madras, from 1,508,238 acres to 1,650,633 acres. The total area in these provinces was 11,132,507 acres in 1880-1, and 12,843,578 acres in 1881 2; an increase of 1,711,071 acres, or in the proportion of $15\frac{1}{2}$ per cent. Bengal is excluded from these figures, no returns of acreage under any crops being furnished, as also are the minor provinces where cotton is grown on an insignificant scale. The Deputy-Commissioner of Wein, in the Hyderabad assigned districts (Berar), estimates the cost of cultivation of cotton, including rent, at Rs.4 8a. 8p. an acre, and the whole value of the out-turn, seed included, at Rs.19 8a. 8p. an acre, which, taking the average yield at 78 lb. to the acre, leaves the cultivater a net profit of Rs.15 an acre. If these figures are at all accurate, the cultivation must be profitable, but the average yield is not so high as 78 lb.; in Berar, it approximates more closely to from 50 lb. to 60 lb. per acre. It may be added that the proportion of the export of Indian cotton to the total export of Indian produce and manufactures, was rather less than 18·4 per cent. in 1881, slightly over 18·8 per cent. in 1882, and rather more than 19·9 per cent. in 1883.

THE *Kreuz Zeitung* announces that the German Government will shortly conclude a treaty of friendship, commerce, and navigation with Zanzibar.

Notes on Books.

INTERNATIONAL HEALTH EXHIBITION LECTURES. London: William Clowes and Sons. 1884.

The lectures delivered during the season, and now published, were devoted to the consideration of the chief objects of the Exhibition. Sir Henry Acland took for his subject, "Village Health and Village Life;" Mr. Eassie dwelt on "Healthy Town and Country Houses," and Mr. Pridgin Teale on "Healthy Homes." Professor Hodgetts delivered two lectures, one on "Anglo-Saxon Dwellings," and another on "Anglo-Saxon Dress and Food." Mr. Lakeman spoke on "Health in the Workshop;" Prof. Corfield on "Foul Air in Houses;" Capt. Douglas Galton on "Ventilation in connection with Warmth and Lighting;" Mr. Ernest Hart on "Smoke Abatement;" and Mr. Edis on "Healthy Furniture." "The Domestic Use of Gas" was Mr. Harold Dixon's subject; "Candles," that of Mr. Leopold Field; and "Soap," that of Mr. C. F. Cross. Of the medical subjects of the lectures, may be mentioned "The History and Results of a Dispensary for Sick Children," by Dr. J. Gibert; "Ambulance Organisation in War and Peace," by Surgeon-Major Evatt; "Our Domestic Poisons," by Mr. Carr; "Ethics of the Skin," by Mr. Malcolm Morris; "Parasites of Meat and Prepared Flesh Food," by Dr. Spencer Cobbold; "Old and Modern Poison Lore," by Mr. Wynter Blyth; and "Prevention of Cholera," by Dr. De Chaumont. Of the lectures devoted to questions of food, there are "Chemistry of Bread-making," by Dr. Charles Graham; "The Æsthetical Use of Wine, and its Influence upon Health," by Dr. Thudichum; "Pure Milk," by Mr. Wigner; "The English Dairy," by Mr. Mariboe; "Dairy Management," by Miss Smithard; "Rearing of Hand-Fed Infants," by Dr. E. Owen; "Science of Cookery," by Mr. Mattieu Williams; "Digestive Ferments," by Dr. Gamgee; and "Practical Dietetics," by Dr. De Chaumont. Of subjects connected with dress, Mr. Wm. Morris dealt with "Textile Fabrics;" Miss Ballin with "Children's Dress;" and the Hon. Mr. Wingfield with the "History of English Dress." Besides these subjects, "Recreation" was treated of by Dr. Darbishire; "Physical Education of Girls," by Miss Chreiman; and "Thrift in its Relation to Health," by Dr. Poore.

HYGIENE: ITS PRINCIPLES AS APPLIED TO PUBLIC HEALTH. Adapted to the requirements of the elementary and advanced stages of the Science and Art Department, the Sanitary Examinations at the Universities, &c. By Edward F. Willoughby. London and Glasgow: William Collins, Sons, and Co.

This work is divided into nine sections, which are arranged as follows. The first is devoted to dietetics,

the second to food stuffs, and the third to water; and in these chapters the scientific and practical effects of food are dealt with. In the fourth section will be found an account of the various points connected with ventilation and heating; the fifth section is devoted to sewage and drainage, and sanitary appliances; the sixth to meteorology and sites; and the seventh section to questions relating to habits, exercise, rest, &c. The last two sections are devoted to clothing and personal hygiene, and to injuries and accidents. There are three appendixes, which contain tables and memoranda on the different subjects treated of.

ENERGY AND MOTION: a Text-book of Elementary Mechanics. By William Pace, M.A. London: Cassell and Company. 1884.

An attempt is here made to bring the subject within the reach of school-boy and school-girl intelligence, and thus to lead up to the study of the more elaborate treatises. The author states that the exercises, with one or two exceptions, are quite new.

TROWEL, CHISEL, AND BRUSH: a Concise Manual of Architecture, Sculpture, and Painting, Ancient and Modern. By Henry Grey. London: Griffith, Farran, Okeden and Welsh. 1884.

Mr. Grey has given in this little book a chronological notice of the chief styles of architecture, and a list of the greatest sculptors and painters, with notes on their works.

ARTISTIC CHRISTMAS AND NEW YEAR CARDS. London: Raphael Tuck and Sons, 72 and 73, Coleman-street, E.C.

Messrs. Tuck have produced for the present season a large number of cards, to the extent of about 400 sets, consisting of 1500 distinct designs. They are designed in a variety of styles, such as (1) chromo-cards, single and folding; (2) twofold, threefold, and fourfold screens; (3) easel cards and portfolio sets; (4) oval and circular chromo-plaques; (5) etchings; (6) satin chromo tablets; (7) frosted cards, and (8) silk and plush covered cards. The larger number of the cards have also designs on the backs.

General Notes.

UNITED STATES PATENTS.—A return prepared by Mr. Commissioner Butterworth shows that nearly 300,000 patents have been issued at various times by the United States Government. The various lines of machinery and industries have received the following numbers respectively:—Metal-working machines, 10,203; stoves and furnaces, 8,230; ploughs, 6,889; mills and threshing, 6,740; harvesters, 6,606; applications of electricity, 5,872; steam-engines, 5,510; lamps and gas fixtures, 5,254; boots and machinery, 5,060; laundry utensils, 4,993; metalling, 3,854; water distributors, 3,717; seeders and planters. 3,568; railway cars, 3,509; railways, 3,504; pumps, 3,156; beds, 2,150; chairs, 1,580; dairy utensils, 2,429; fences, 2,888; methods of tanning hides, 1,218; wearing apparel, 2,479; artesian wells, 500; bread and cracker machinery, 440; corset patters, 969; fire-engines, 567; fire-escapes, 884; machines for knitting, 754; nut and bolt locks, 734; and vegetable cutters, 459. These amounted in the whole to 104,217, or a little over one-third of the entire number of patents issued.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

DECEMBER 3.—"Electric Lighting in America." By W. H. PREECE, F.R.S. Sir FREDERICK BRAMWELL, F.R.S., Member of Council, will preside.

DECEMBER 10.—"The Preparation of Butterine." By ANTON JURGENS.

DECEMBER 17.—"Present and Prospective Sources of the Timber Supplies of Great Britain." By P. L. SIMMONDS.

At the meetings after Christmas, the following Papers (among others) will be read.

"The Employment of Hydraulic Machinery in Engineering Workshops." By RALPH H. TWEDDELL.

"The History and Manufacture of Playing Cards." By GEORGE CLULOW.

"The Musical Scales of Various Nations." By A. J. ELLIS, B.A., F.R.S.

"Sea Fisheries." By Prof. E. RAY LANKESTER, M.A., F.R.S.

"Labour and Wages in the United States." By D. PIDGEON.

"Recent Improvements in Coast Signals." By Sir J. N. DOUGLASS.

"The Influence of Civilisation upon Eyesight." By R. BRUDENELL CARTER, F.R.C.S.

"The Evolution of Machines." By Prof. H. S. HELE SHAW.

"Tempered Glass." By FREDERICK SIEMENS.

"Past and Present Methods of Supplying Steam Boilers with Water." By W. D. SCOTT MONCRIEFF, M.Inst. C.E.

HOWARD LECTURES.

Thursday evenings at Eight o'clock.

A special Course will be delivered under the Howard Trust, on "The Conversion of Heat into Useful Work." By W. ANDERSON, M.Inst.C.E.

LECTURE II. DEC. 4.—Oscillation, Vibration, Wave Motion, Pulsation in Liquids and Fluids. The Luminiferous Ether. Porosity of Matter; ultimate Structure of matter. Heat the consequence of Molecular Motion. Transparency. Diathermancy. Specific Heat. Unit of Heat. Latent Heat. Absolute Zero of Temperature.

LECTURE III. DECEMBER 11.—Molecule Theory of Gases. Laws of Volume, Pressure, and Temperature. Isothermal and Adiabatic Lines of Permanent Gases and of Vapours. Joule's equivalent. The doctrines of Carnot. The Limits of Efficiency of Heat-engines.

LECTURE IV. JANUARY 22.—The working substances in Heat-engines. Gunpowder Gases. Coal Gas. Hot Air. Steam. The method and cost of preparing the working substances. The theoretical Calorific Power of Fuels, the Degree of Efficiency to be expected, and the Efficiency actually realised.

LECTURE V. JANUARY 29.—The Discharge of Artillery; Work done on the Projectile, and on the Gun and Carriage; Limits of Efficiency. Gas-engines; Nature of their Action, Mechanical details, Limits of Efficiency, Results actually obtained.

LECTURE VI. FEBRUARY 5.—Hot Air-engines; Nature of their Action, Mechanical details, Limits of Efficiency. Compressed Air Refrigerating Machines. The Steam-engine, Non-condensing, Condensing, and Compound; Nature of its Action, Mechanical details, Limits of Efficiency, Results actually obtained.

CANTOR LECTURES.

Monday Evenings at Eight o'clock. The First Course will be on "The Use of Coal Gas." By HAROLD B. DIXON, M.A.

LECTURE I. DEC. 1.—The composition of Coal Gas, its properties, its combustion.

LECTURE II. DEC. 8.—Coal Gas as a source of Light.

LECTURE III. DEC. 15.—Coal Gas as a source of Heat.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DEC. 1...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Harold B. Dixon, "The Use of Coal Gas." (Lecture I.)
Royal, Burlington-house, W., 4 p.m. Annual Meeting.
Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.
Chemical Industry (London Section), Burlington-house, W., 8 p.m. Mr. J. M. Thomson, "Photography for those engaged in Industrial Pursuits."
British Architects, 9, Conduit-street, W., 8 p.m. Adjourned discussion on Mr. H. Stannus's paper, "The Internal Treatment of Cupolas in general, and that of St. Paul's Cathedral in particular.
Medical, 11, Chandos-street, W., 8½ p.m.
Victoria Institute, 7, Adelphi-terrace, W.C., 8 pm.
London Institution, Finsbury-circus, E.C., 5 p.m. Rev. W. Benham, "The French Revolution." (Lecture V.)

TUESDAY, DEC. 2...Civil Engineers, Great George-street, S.W., 8 p.m. 1. Hon. R. C. Parsons, "The Working of Tramways by Steam." 2. Mr. W. Shellshear, "The Sydney Steam Tramways."
Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.
Biblical Archæology, 9, Conduit-street, W., 8 p.m.
Zoological, 11, Hanover-square, W., 8½ p.m. 1. Prof. E. Jeffrey Bell, "Sudies in the Holothuroidea. (No. V.) "Further Notes on the Cotton Spinner." 2. Rev. A. M. Norman and Rev. T. R. R. Stebbing, "The Crustacea Isopoda of the *Lightning*, *Porcupine*, and *Valorous* Expeditions." 3. Mr. J. Bland Sutton, "Observations on the Parasphenoid, the Vomer, and the Palato-pterygoid Arcade." 4. Mr. G. A. Boulenger, "Notes on the Edible Frog in England."

WEDNESDAY, DEC. 3...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. W. H. Preece, "Electric Lighting in America."
Geological, Burlington-house, S.W., 8 p.m. 1. Prof. A. H. Green, "Note on a Section near Llanberis." 2. Mr. J. Starkie Gardner, "The Tertiary Basaltic Formation in Iceland." 3. Mr. J. Starkie Gardner, "The Lower Eocene Plant-beds of the Basaltic Formation of Ulster." 4. Mr. George Robert Vine, "Notes on Species of *Phyllopora* and *Thamniscus* from the Lower-Silurian Rocks, near Welshpool, Wales."
Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m. Prof. Redwood, "Liquid Extract of Cinchona."
Sanitary Assurance Association, 74A, Margaret-street, W. 7½ p m. Dr. Norman Chevers, "House Sanitation."
Entomological, 11, Chandos-street, W., 7 p.m.
Royal Society of Literature, 4, St. Martin's-place, W.C. 8 p.m.
Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. Thos. Morgan, "*Résumé* of the Tenby Congress." 2. Mr. C. Lynam, "The Inscription on the Cross at Carew." 3. Geo. K. Wright, "The Maunday Distribution."
Obstetrical, 53, Berners-street, W., 8 p.m,
Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7½ p.m. Opening Address by the President, Mr. T. Coles.

THURSDAY, DEC. 4 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Howard Lectures.) Mr. W. Anderson, "The Conversion of Heat into Useful Work." (Lecture II.)
Antiquaries, Burlington-house, W., 8½ p.m.
Linnean, Burlington-house, W., 8 p.m. 1. Mr. Alfred Tylor, "Motion of Trees and Continuity of Protoplasm." 2. Mr. Jas. W. Davis, "*Heterolepidotus grandis*, a Fossil Fish from the Lias."
Chemical, Burlington-house, W., 8 p.m.
London Institution, Finsbury-circus, E.C., 7 p.m. Rev. W. Benham, "The French Revolution." (Lecture VI.)
South London Photographic (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m.

FRIDAY, DEC. 5...Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. Harley H. Dalrymple-Hay, "Trigonometrical Surveying."
Geologists' Association, University College, W.C., 8 p.m. 1. Mr. Ralph Meldola, "Preliminary Notice of the East Anglian Earthquake of April 22nd, 1884." 2. Mr. Henry Hicks, "Some Recent Views concerning the Geology of the North-West Highlands."
Philological, University College, W.C., 8 p.m. Rev. Dr. Richard Morris, "Pali Miscellanies."

Journal of the Society of Arts.

No. 1,672. Vol. XXXIII.

FRIDAY, DECEMBER 5, 1884.

All communications for the Society should be addressed to Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

The usual short course of lectures, adapted for a juvenile audience, will be given on Wednesday evenings, December 31st, 1884, and January 7th, 1885, by Professor J. Norman Lockyer, F.R.S., on "Universal Time: our Future Clocks and Watches." The lectures will commence at seven o'clock. A sufficient number of tickets to fill the room will be issued to members in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each member is entitled to a ticket admitting two children and one adult. Tickets are now in course of distribution, and members requiring them should apply at once.

DR. RICHARDSON'S LECTURE.

A lecture on "The Painless Extinction of Life in the Lower Animals," will be delivered by W. B. Richardson, M.A., M.D., F.R.S., on Tuesday afternoon, December 16th, at 4 p.m.

HOWARD LECTURES.

On Thursday evening, November 27th, Mr. W. Anderson, M.Inst.C.E., delivered the first of the Howard Lectures, on "The Conversion of Heat into Useful Work."

CANTOR LECTURES.

Mr. Harold B. Dixon, M.A., delivered the first lecture of the first course of Cantor Lectures, on the "Use of Coal Gas," on Monday evening, December 1st. The special subject of the lecture was "The Composition of Coal Gas, its Properties, and Combustion."

INDIAN SECTION COMMITTEE.

Colonel Hardy, who has acted as Secretary of the Indian Section since 1875, has resigned this office, and the Council, having accepted his resignation with great regret, have appointed Mr. Demetrius G. Boulger in his place.

A meeting of the Committee of the Section was held on Thursday, November 27, at 4 p.m. Present:—Sir W. Rose Robinson, K.C.S.I., in the chair, Sir George Birdwood, M.D., C.S.I., Mr. Hyde Clarke, and Mr. J. M. Maclean, with Mr. H. Trueman Wood, Secretary, and Mr. Demetrius G. Boulger, Secretary of the Section. The programme of papers to be read during the present Session was discussed.

THE TEN-VOLUME INDEX TO "JOURNAL."

The index to the *Journal of the Society of Arts*, volumes xxi. to xxx. (1872-82), is now ready, and can be obtained gratis by members on application to the Secretary, John-street, Adelphi.

Some copies of the two previous ten-volume indexes are still in stock, and can also be obtained by members on application.

The price to non-members of each index is half-a-crown.

Proceedings of the Society.

THIRD ORDINARY MEETING.

Wednesday, December 3, 1884; Sir Frederick Bramwell, F.R.S., Member of the Council of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Bidwell, Shelford, Riverstone-lodge, Wandsworth, S.W.
Binswanger, Gustav, 29, Aldermanbury, E.C.
Coscia, C. F., 20, Wellington-square, Oxford.
Glover, James William, Ranelagh Works, Royal-avenue, Chelsea, S.W.

Laurence, Reginald, Cavendish-road, Clapham-park, S.W.
McLauchlan, David, 29, Union-grove, Clapham, S.W.
McMinn, Arthur Charles, Western-house, Kensal-green, W.
Müller, Hugo, Ph.D., F.R.S., 110, Bunhill-row, E.C.
Oliver, John H., 123, Stamford-street, S.E.
Rickard, John Perrott, junior, 5, Motcombe-street, Belgrave-square, S.W.
Roberts, Thomas, Portmadoc.
Turner, H. H., 9, Humber-road, Westcombe-park, Blackheath, S.E.
Wyles, Frederic, Telegraph Department, Waterloo Station, L. & S.W.R., S.E.

The following candidates were balloted for and duly elected members of the Society:—

Adams, William, Salisbury-house, Upper Richmond-road, Putney, S.W.
Ainslie, Francis Sawer, Ulverston.
Anderson, A. Hay, 15, Coleman-street, E.C.
Archer, J. A., Waverley, Lordship-lane, S.E.
Ashby, Henry, Staines.
Aubert, William, jun., Crossgates-house, Balham, S.W.
Baker, Arthur Henry, Elderslie, South Eden-park, Beckenham, Kent.
Barlow, Robert, M.R.C.S., Norfolk-house, Dalston, E.
Barrett, C. H., Middleburg, Transvaal, South Africa.
Baxter, Samuel, 18 and 19, Great St. Helen's, E.C.
Beavis, George, 6, Lancaster-road south, Upper Tollington-park, N.
Bell, John Ferguson, Stafford.
Bemrose, William, Elmhurst, Derby.
Blackham, William Philip, 1, Hyde-park-villas, St. James-road, Wandsworth-common, S.W.
Botting, Francis, 6, Baker-street, W.
Bridgman, Henry Hewitt, 42, Poultry, E.C.
Bright, Charles, 20, Bolton-gardens, S.W.
Bright, Edward Brailsford, 31, Golden-square, W.
Brocklehurst, Septimus, Red Cross-street, Liverpool.
Brown, Harold, Howe-foot, 20, Fitzjohn's-avenue, N.W.
Brownlow, Capt. Arthur, R.N., C.B., Mourne, Beckenham, Kent.
Bryant, William James, Seal, Sevenoaks, Kent.
Buckney, Daniel, Croxton-road, Dulwich, S.E.
Burgess, Henry Edward, 5, Charles-street, Grosvenor-square, W.
Chapman, Edward, M.A., F.C.S., Frewen-hall, Oxford.
Chapman, Henry, Hampton-villa, Upper Harefield-road, Brockley, S.E.
Chappuis, Paul Emile, 69, Fleet-street, E.C.
Cheesman, Walter Nightingale, The Hall, Dulwich, S.E.
Colam, William Newby, 2, Victoria-mansions, Westminster, S.W.
Cooke, Frederick George, Trinity-chambers, Eastbourne.
Cotterill, Prof. James H., F.R.S., 18, Gloucester-place, Greenwich, S.E.
Cox, Edmund Penley, Bahia, Brazil.
Crofton, Lieut-Gen. James, R.E., 12, Westbourne-square, W.
Croyle, James, 38, West-hill, Sydenham, S.E.
D'Alton, Patrick Walter, London Mutual Boiler Insurance Co., 17, Queen Victoria-street, E.C.
Davies, Philip John, 78, Earl's-court-road, Kensington, W.
Dempster, Duncan Ferguson, 4, Glenfinlas-street, Edinburgh.
Devey, Arthur Charles, Lucan-lodge, Clapham-park, S.W.
Devoll, William, 3, Boldmere-road, Erdington, Birmingham.
Dismoor, James Stewart, Stewart-house, Gravesend.
Dougall, Andrew, British Gasworks, Hull.
Duka, Surgeon-Major T., M.D., 55, Nevern-square, S.W.
Eads, James B., 40, West Fifty-third-street, New York.
Eaton, William M., 16, Prince's-gate, Hyde-park, S.W.
Edwards, Col. James Bevan, C.B., York.
Evans, C. J. Mackenzie, 42, Chelsham-road, Clapham, S.W.
Evans, Stanley, 20, Theobald's-road, Bedford-row, W.C.
Falconer, David, 27, Marmora-road, Honor Oak, S.E.
Floyd, Capt. C. Ashburnham, Powys, Eastbourne.
Focking, Mrs. (Anne), 15, Bayswater-terrace, W.
Forester, F. W., Waylands, Beckenham, Kent.
Gale, Miss, 22, Albemarle-street, W.
Galloway, W., The Cottage, Llandaff.
Galt, Hon. Sir Alexander T., G.C.M.G., 79, Cambridge-terrace, Hyde-park, W.
Gemmell, Thomas, 45, Gloucester-street, Warwick-square, S.W.
Gildea, Major James, 20, Phillimore-gardens, Kensington, W., and Holme Bury, Watford, Herts.
Gill, Mason, 21, Commercial-street, Huddersfield.
Goldie, John Harrison, 7, Temple-street, Swansea.
Gore, John Ellard, Beltra, Ballisodare, Co. Sligo, Ireland.
Green, Walter James, 194, High-street, Watford.
Gunning, Robert Halliday, M.A., M.D., 30, Hazlitt-road, West Kensington-park, W.
Harker, Henry, 37, Walbrook, E.C.
Harris, Henry George, 17 and 18, Upper George-street, Bryanston-square, W.
Harrison, William G., Atherton-house, Birdhurst-rise, South Croydon.
Hassall, Abner, Cleveland-house, Southgate-road, Wood Green, N.
Hill, William Edward, 37, Stokes-croft, Bristol.
Hovenden, Albert, Oaklands, Haling-park-road, Croydon.
Hutton, Leonard John, Merlewood, Bickley, Kent.

Hutton, Percy Edward Septimus, 6, Newgate-street, E.C.
Inverarity, George, 13, Stanhope-gardens, S.W.
James, Joseph Brindley, M.R.C.S., 47, Jamaica-road, Bermondsey, S.E.
Johnson, Samuel W., Linton-house, The Park, Nottingham.
Jones, H. E., Commercial Gasworks, Stepney, E.
Jones, James, jun., 3, Amersham-park-villas, Park-road, New Cross, S.E.
Kay, Samuel, Charlestown-house, Bramhall - lane, near Stockport.
Kay, Thomas, Moorfield, Stockport.
Kennedy, Prof. Alexander B. W., University College, W.C.
Kennedy, Charles Malcolm, C.B., 27, Kensington-gate, W.
Knill, John, South-vale-house, Blackheath, S.E.
Lammers, Carl Leonhard Herman, 2, Roseworth-terrace, Gosforth, Newcastle-on-Tyne.
Langdon-Down, J., M.D., 81, Harley-street, W.
Langham, James George, Westdown, Eastbourne.
Lavender, H. P., Cleveland Safe and Lock Works, Cleveland-street, Wolverhampton.
Lawder, James Ormsby, Lawderdale, Co. Leitrim.
Lawrence, Frederick W., Oakleigh, Beckenham, Kent.
Lawson, William Taylor, 161, Gresham-house, Old Broad-street, E.C.
Leon, Arthur Lewis, 34, James-street, Buckingham-gate, S.W.
Lester, Kenneth Campbell, 12, Saltram-villas, St. Peter's-park, W.
Lewis, Colonel W. B., R.A., The High Beach, Hollington, near St. Leonards-on-Sea.
Ley, Rev. William Clement, M.A., Bulwark-house, St. Aubyn's, Jersey.
List, John, 6, Upper St. Germain's-terrace, Blackheath, S.E.
Lockyer, George, 1, Gresham-buildings, Basinghall-street, E.C.
Main, William C., Arundel-house, 70A, Ladbroke-grove, W.
Malpass, John, Abbey-street, Derby.
Marshall, Henry W., 4, Adam's-court, Old Broad-street, E.C.
Martin, Miss Harriet Ann, High School for Girls, Sidney-place, Cork.
Matthews, Henry Thomas, The Mount, Hadley, Barnet.
Montalba, August, 20, Stanley-crescent, W.
Mortimer, Captain Stanley, 7, Observatory-gardens, Kensington, W.
Mullord, Alexander, 99, Mortimer-road, De Beauvoir-square, N.
Ness, Patrick, Kent-house, 1, Lansdowne - road, Notting-hill, W.
O'Callaghan, Guy Morgan Scott, 13, South-square, Gray's-inn, W.C., and Wanderers' Club, S.W.
Odling, William, M.B., F.R.S., 15, Norham-gardens, Oxford.
Ogle, Bertram, Hill-house, Steeple Aston, Oxon.
Ogle, John, 32, Redcliffe-square, S.W.
Ortelli, Chevalier John, 35, Brunswick-square, W.C.
Park, John C., Blenheim-house, Bow-road, Bow, E.
Parkes, James Unitt, Holmwood, Carlton-road, Putney, S.W.
Partridge, W. S., Elmshade, Reigate.
Pocock, Alfred, 233, Southwark-bridge-road, S.E.
Podzus, Jabez, 15, Lamb's Conduit-street, W.C.
Ponsonby, General the Right Hon. Sir Henry, K.C.B., St. James's-palace, S.W.
Prestige, John Theodore, Hulme-house, Wickham-road, Brockley, S.E.
Price, William Edward, Gas Works, Hampton-wick.
Prince, Henry, 15, Walbrook, E.C.
Purdey, Athol Stuart, 28, Devonshire-place, Portland-place, W.
Ráth, Ferdinand, Léontine-villa, Hornsey, N.
Rayner, Thomas Cheveley, Limavady and Dungiven Railway, Limavady, Co. Londonderry.
Read, Richard, Gloucester.
Richardson, Joseph, 15, Fetter-lane, E.C., and 63, Haymarket, S.W.
Robinson, F. R., Atlas Paper Works, Newington-causeway, S.E.
Robson, Bartholomew, Mayfield-lodge, Vanbrugh-fields, Blackheath, S.E.
Rome, William, 158, Cheapside, E.C., and The Red lodge, Putney, S.W.
Rowlett, William Tertius, 34, Newarke - street, Leicester.
Sacré, Alfred L., 60, Queen Victoria-street, E.C.
Salomons, Leopold, 23, Bruton-street, Berkeley-square, W.
Sandars, Samuel, 7, De Vere-gardens, Kensington, W.
Sconce, Gideon Colquhoun, 63, Prince's-square, Bayswater, W.
Scott, Charles Clare, 3, Elm-court, Temple, E.C.
Seton, David Elphinstone, M D., 12, Thurloe-place, South Kensington, S.W.
Seton-Orr, Dr. A. B., 45, Sussex-place, South Kensington, S.W.
Sharpe, Rev. Thomas Wetherherd, M.A., Beddington, Croydon.
Smith, E. Noble, F.R.C.S.E., 24, Queen Anne-street, W.
Smith, George Henry, Park-house, Halifax.
Smith, Josiah, 51, Park-end-road, Gloucester.
Smith, Urban Armstrong, County Surveyor's-office, Hertford.
Spicer, James, J.P., Harts, Woodford, Essex.
Spreckley, Thomas Freer, Freeby, Sidcup, Kent, and 13 and 15, Cannon-street, E.C.
Suffield, Thomas, Farnham, Surrey.
Suft, Charles, Duke of Wellington's Regiment, the Barracks, Tipperary.
Talman, J. J., The Grange, Harbledown, near Canterbury.
Tavener, Stephen N., Great Bedwyn School House, Hungerford.

Taylor, General Sir Alexander, K.C.B., Cooper's-hill, Englefield-green, Surrey.
Thomas, James Lewis, F.S.A., Horse Guards, S.W.
Thomasson, Mrs. (Katherine), 4, Grosvenor-crescent, S.W.
Thorpe, Thomas, 10, Beech-avenue, New Basford, Notts.
Thrupp, Leonard William, 67, Kensington-gardens-square, Bayswater, W.
Thurlow, Right Hon. Lord, 33, Chesham-pl. S.W.
Topley, W., Geological Survey-office, 21, Jermyn-street, S.W.
Tucker, Miss Mildred Anna Rosalie, 4, Oxford and Cambridge-mansions, N.W.
Turner, Thomas, Saville-town, Dewsbury.
Twelvetrees, Walter Noble, 8, City-road, E.C., and Hargrave-house, Enfield.
Wallace, Robert H., Rosa, N.W.P., India, and Newton-hall, Kennoway, Fife.
Wallis, Arthur Herbert, Coombehurst, Basingstoke.
Whelpton, Edward Smith, Antron-house, Upper Tulse-hill, S.W.
Wilson Andrew, Santander, Coventry-road, Streatham, S.W.
Winn, William, 6, Duke-street, Adelphi, W.C.
Wire, Alfred Philip, 1, Seaton-villas, Birkbeck-road, Leytonstone, E.
Wolfsky, Moritz, Kurrachee, High-road, Streatham, S. W.
Wright, Henry Edward, 89, Piccadilly, W.
Wright, William Barton, Balmadies, Prestwick, near Manchester.
Wyman, William Sanderson, M.D., 280, Upper Richmond-road, Putney, S.W.

The paper read was—

ELECTRIC LIGHTING IN AMERICA.

By W. H. Preece, F.R.S.

Electric lighting is flourishing in America much more than at home. There are, probably, 90,000 arc lamps alight every night in the States, and there are many central stations working regularly, both with arc and with glow lamps.

I know nothing more dismal than to be transplanted from the brilliantly illuminated avenues of New York to the dull and dark streets of London. This has happened to me very recently. On the evening of October 21st, I drove from the Windsor Hotel, New York, to the Cunard Wharf, a distance of about four miles, through streets entirely lighted by electricity. On October 30th, I drove from Euston to Waterloo without seeing a single electric light, having been on the ocean during the intervening period.

I visited Montreal, Philadelphia, Buffalo, Cleveland, Chicago, St. Louis, Indianapolis, Boston, and New York; finding in each city the principal streets and warehouses, as well as stores and places of public resort, lighted by arc lamps. After so much brilliance in these cities, the return to dull gas has a most depressing influence.

It is with arc lighting that the greatest advances have been made in the States. One manufacturer alone told me that he was turning out 800,000 carbons for arc lamps per month; and another said that his output of plant was fifty arc lamps and three dynamos per day; and while I was present at a third factory, an order was received for an electric lighting plant of 330 arc lamps requiring fourteen 24-light dynamo machines, intended for an installation to light up a driving park in the environs of Chicago.

As an instance of the growth of electric lighting, I may mention that in Chicago the number of arc lamps installed has doubled, viz., from 1,000 to 2,000, during the past twelve months, and the number increases daily. More than one electric light company pays dividends to its shareholders, and all of the manufacturers as well as the lighting companies seem to be full of work.

The principal systems in use are, for arc lamps—the Brush, the Weston, the Thomson-Houston; but there are other arc systems, not so well known on this side of the Atlantic, such as the Hochhausen, the Van de Poel, the Western Electric, the Fuller, the Sperry, &c. For glow lamps—the Edison, and the Weston. I will describe briefly the systems I saw in use, dividing them into (1) arc systems and (2) incandescent systems.

I.—Arc Systems.

The Brush System is so well known that it scarcely needs any reference, excepting to point out that a very considerable improvement has recently been made in the dynamo machine, which has very largely increased its capacity and output. The new Brush armature consists of layers of thin sheet iron, insulated from one another. By this arrangement, induced currents—improperly called "Foucault" currents, for they were fully described by Joule as far back as 1843—which produce heat, and thereby diminish the efficiency of the machine, are prevented from being formed; and further, should heat arise through excess of current, thorough ventilation is effected to carry it away by convection. Brush dynamos which previously, with the old armature, lighted

sixteen and forty lamps respectively, now, with the new armature, excite thirty lamps and sixty-five lamps; so that it will be seen that the improvement is very considerable.

The Weston System.—This system, looked at from a mechanical point of view, strikes one as being probably the best in use in the States. The machine itself is of the Siemens form, but the armature is made up of discs stamped out of thin sheet iron, and separated from one another by washers. By this method, first suggested by Joule in 1843, those disturbing induced currents are entirely checked, and thereby the undue heating of the armature is prevented. Mr. Weston appears to have been the first to have practically carried out this very sensible idea, and it is being rapidly adopted by other makers of dynamo-machines. I have mentioned that Mr. Brush has followed out the same plan.

The commutator in the Weston machine differs from most American commutators, in that it has no less than 140 segments, which tend to prevent "sparking," a very disturbing element in the action of dynamos. In fact, the absence of sparks is one of the striking features of this machine.

There are standard Weston machines for working arc lamps, and also for working glow lamps. Both kinds are shunt wound, the former being supplied with a most sensitive and extremely ingenious regulator, which adjusts the strength of the shunt current or field magnets, so as to maintain the current in the main line constant. The 200-light Weston dynamo for glow lamps is peculiar in the extreme lowness of the resistance of the armature, which is only 0011 ohm, while the resistance of the shunt is 24 ohms, thus having a ratio between them of 1 to 2182. The result of this lowness of resistance is that the resistance of the armature may be neglected, and therefore the dynamo becomes self-regulating. I saw 199 lamps out of 200 suddenly extinguished, without producing any apparent change in the incandescence of the one glow lamp left. The electromotive force of this machine is 70 volts when rotated at 1,000 revolutions per minute.

The arc lamps of the Weston type do not call for special notice, excepting to record the remarkable steadiness of their burning. They are fed on the differential principle, but they owe their steadiness and good working to the perfection of workmanship and the mechanical finish of their parts.

The beautiful suspension bridge at Brooklyn is lighted entirely by eighty-two Weston lamps. This is done by the bridge trustees themselves. The view of this lofty bridge at night from Staten Island, and from the magnificent harbour of New York, is one of the prettiest optical effects I have ever seen.

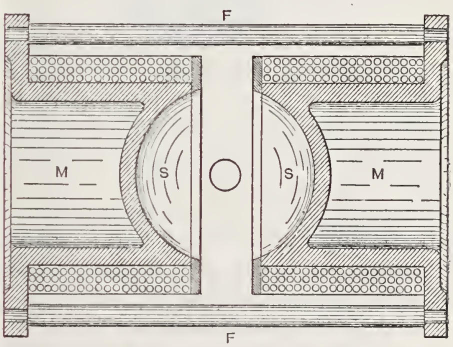
New York harbour will soon be so brilliantly illuminated by electric lights that one of the enterprising ferry companies contemplates having nightly excursions, which it is intended to advertise as the "Theatre of New York Harbour by Electric Light; price of admission 10 cents."

Local companies using the Weston arc system are successfully operating central stations, supplying a large number of lights for rental at Boston; Springfield; Manchester; Providence, Rhode Island; Newport, Rhode Island; New York City; Rochester; Elmira and Glen Falls, New York; Newark; Cape May; Atlantic City, &c.

The Thomson-Houston System.—This system is unknown at present in England; it contains some considerable and ingenious novelties.

The field-magnets of the dynamo are of the peculiar shape shown in Fig. 1. The space M

FIG. 1.



THOMSON-HOUSTON DYNAMO.

is round and hollow, and the two parts are strongly bolted together with 18 bars of soft iron, F F, leaving a spherical space, S, for the field.

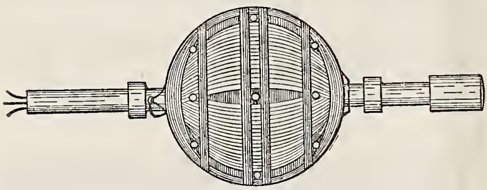
The armature (Fig. 2, p. 68) is spherical, and is almost entirely encased by the field-magnets, the magnetic field thereby becomes enclosed, and is very intense.

The dynamo is series wound. The commutator consists of only three sections, and there are two pairs of brushes. It has an automatic governor, which adjusts the lead of the brushes to positions of varying electromotive force as the work itself varies, so that,

however much the number of lamps may change, the current remains steady. It has a peculiar air-blast device, to prevent undue sparking at the brushes; strong currents or puffs of air prevent the formation of those lines of minute conducting particles which bridge across the air spaces at the commutator, and whose presence forms one cause of so-called "flashing," and they blow out the sparks which would form at the brushes. The arrangement also admits of the free oiling of the commutator, a point of very considerable importance, at a place where there is so much wear; it is a peculiarity of this dynamo.

The ordinary size Thomson-Houston dynamo lights up twenty-five arc lamps, and it has 225 lbs. of copper on the armature, and 700 lbs. on the field-magnet. When rotated at the ordinary speed of about 900 revolutions per minute, it acquires an electromotive force of 1,200 volts, and generates a current of 9·8 ampères in the lamp circuit.

Fig. 2.



Armature.

The lamps have an average resistance of 4·5 ohms, and the electromotive force that each lamp takes is 45 volts. A 25-lamp circuit absorbs 23·25 horse-power. The commercial efficiency of this machine is, therefore, 80 per cent. Frequently, as many as seven of these dynamos are joined up in series. An interesting example of lighting is that of a new swing bridge crossing the river at Rush-street, Chicago, which is moved with promptitude and lighted with brilliance by steam-engines fixed in the centre of the bridge. All connection with the shore is cut off when opening, but the whole thing works with great steadiness, although a heavy traffic, four abreast, is maintained all day long.

The Hochhausen System.—This is slightly known in England, from its employment in the recent International Health Exhibition to light up the tall mast in the centre of the gardens, but it has scarcely received the attention that it merits. It is doing a large business, but I did not visit any places worked by it.

Central Stations.—I visited the central station of the Thomson-Houston Company at Montreal. It was opened on the 14th March last, and on September 3rd, when I was there, there were 164 arc lamps alight in the public streets and shops of the town. The wires through the town were all of copper, principally No. 6 gauge, covered with cotton and asbestos, and were in all cases carried through the streets on unsightly posts. The rate charged is 50 cents per lamp per night, the lamps being lighted from dark to midnight; this means over £35 per lamp per annum.

I visited other central stations worked on this system, and I learned that it was decided to light up the public streets of Ottawa entirely by the Thomson-Houston system. In that case the power will be obtained from the celebrated Chaudiére Falls, that add so much picturesqueness to the position of Ottawa and wealth to its inhabitants, for they provide the great source of power used to carry on the timber trade of the place.

Another central station that I inspected was that of the Brush system, at Philadelphia; there 1,200 horse-power was employed in supplying electricity for nearly 1,000 lamps. As in Montreal, open wires are used, supplying 25 circuits, some of which are four miles long. The charge for each lamp is 25 dollars per month, which is equal to £60 per lamp per annum.

The Brush people have also two central stations at Boston, lighting up 816 arc lamps; in fact few towns of any consequence in the States do not possess central stations worked by the Brush Company. There are, probably, 25,000 Brush arc lamps in use in the States.

At Chicago there are now over 2,000 arc lamps going, and they are increasing in number every day. The Lincoln-park has all its drives lighted by arc lamps, with very great effect, especially on the unique drive skirting the shore of Lake Michigan. There are several central stations belonging to various companies in Chicago, viz., the Western Electric, the Van de Poel, the Fuller, and the Sperry Company; while the Hochhausen system is about to be started with a central station for several hundred lamps.

I did not observe any particular novelty in the form of lamps used, and the impression I gained was that there were some European lamps that far surpassed the American ones in steadiness and efficacy.

Street Lighting.—I did not see in the

States one single instance of street lighting by glow lamps. In every case arc lamps were used for this purpose, and they were usually fixed on much taller posts than we are accustomed to see in England, arranged in zigzag fashion along the streets, at a distance from each other of about fifty yards. Although the effect of this street lighting by arc lamps was brilliant, it was by no means perfect, and no effort seems to have been made to distribute the light uniformly, as has been done in England by Mr. Trotter; and, in fact, the question does not seem to have been attacked at all from a scientific point of view. The commercial spirit alone appears to have been exercised in developing this enterprise.

An interesting experiment has been tried in Cleveland, where eight Brush lamps are fixed upon the tops of four iron masts, each about 250 feet high, fixed in prominent positions in the city. These masts were made of rivetted boiler-plate. They were erected *in situ*, and raised by jacks as they were made. The diameter is eight inches at the top and three feet at the bottom; they cost £800 each. I am bound to say that, to me, the effect was very poor; the streets were illuminated only by a light equal to a very pale moonlight. There are 300 other arc lamps in Cleveland.

At St. Louis, the court-house in the centre of the town was surrounded by permanent arc lamps, but, though they illuminated the dome of the court-house itself, the effect upon the contiguous streets was poor. Here one of the streets was lighted by two arc lamps on each pole on one side of the street, and the effect was certainly indifferent, and gave one the idea of a great waste of light.

Washington has been experimentally illuminated by the Brush-Swan Electric Light Company, by very large arc lamps, 4,000 candle-power each, fitted with large conical reflectors, throwing a great body of light down the streets to be illuminated. The various avenues radiating from the Capitol are thus lighted, and a circle of fourteen lights, without reflectors, surrounds the top of the Capitol, the effect of which I am told is certainly very fine. I have since learned, however, that, after an experimental run of forty-five days of these lights, the commissioners empowered to decide upon the success of the experiment have given their veto against its continuance.

It is, perhaps, interesting to point out that [illegible] price paid in New York is 70 cents per [illegible], or £50 per annum for each arc lamp; but a fine is inflicted on the lighting company of 1·40 dollars for each time that each lamp is reported to have been out; a healthy check is thus kept upon the good working of the system.

II.—Incandescent Systems.

Incandescent lighting in America does not seem to have flourished to the same extent as arc lighting, nor indeed has it been applied to private houses to the same extent that it has in England; although there are several central stations at work over there, which is not the case on this side of the water. The principal system in practical use is that of Edison. Some incandescent lamps have recently been introduced by Mr. Weston that promise to be very efficient indeed. They are made from a material that Mr. Weston calls "Tamidine," the result of some secret process upon nitro-cellulose. This tamidine is rolled out into very thin sheets, and the filament is stamped out of it in a wavy form by dies. It is then carbonised. Carbon is deposited upon this filament until it acquires a standard resistance, and the process is self-acting so that great regularity is maintained in the resistance of the filament. The whole process of manufacture is extremely ingenious, and I watched it in Weston's manufactory with great interest.

The Swan Lamp is extensively used, principally by the Brush Company.

The Bernstein, a new lamp, which was exhibited at the Health Exhibition, is also commencing to get a footing in the States.

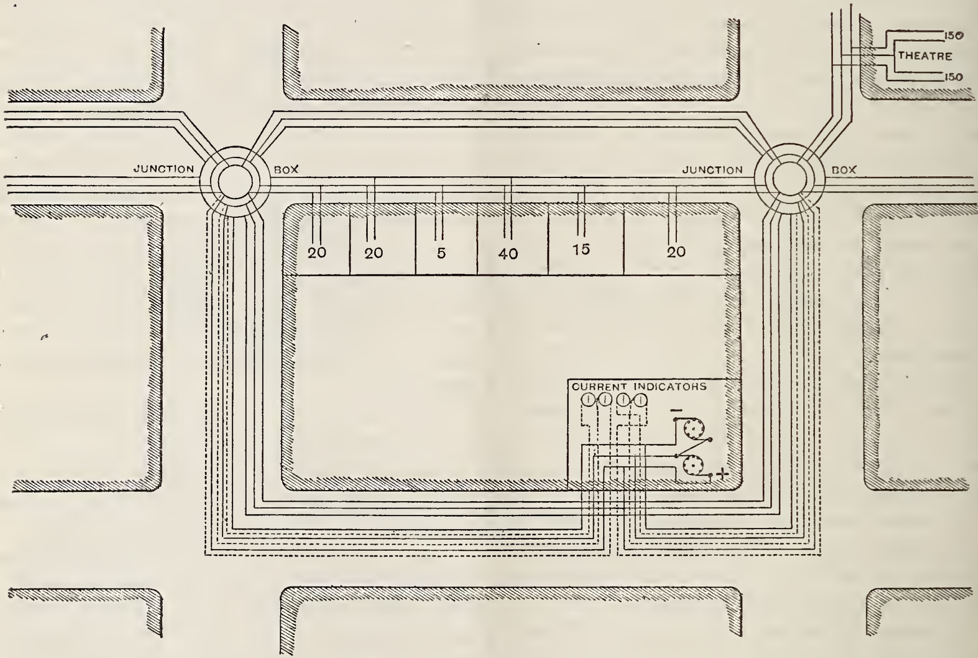
House Lighting.—House lighting has been attacked principally by the Edison Company. The Edison Company have a grand central station in New York, which was opened on the 3rd September, 1882, and during the whole of the period that has elapsed from that time to the date of my visit, there had been only two and a-half hours' stoppage, that being due solely to carelessness. A commodious building in Pearl-street is applied to this purpose.

There are now 587 subscribers, using altogether 12,764 lamps, served day and night; and the present arrangements of the company are quite inadequate to supply all the applicants who desire the light. The price charged is the same as that which would be paid if gas were supplied at 7s. 9d. per 1,000 cubic feet, but there is every reason to believe that the rate is too small, and does not give a sufficient margin of profit. The price of gas is 5s. 9d. per 1,000

cubic feet. It is interesting, however, to know that the system is worked at a profit, and that during the past twelve months the balance on the right side has been sufficient to pay a dividend of 3 per cent. on the capital invested, but no dividend has yet been declared. The earnings per lamp-hour are 1·04 cents, while the cost of production for the same period is ·75 cents. The Board of Trade unit, which was intended to form the basis of charges made for the supply of electricity under the hasty and abortive Act of 1882, in this country, was equal to 1,000 watt-hours. Now an Edison 16-candle lamp absorbs 80 watts, and, therefore, 12·5 lamps alight for one hour would consume a B.T. unit. These lamps would cost in New York 15 cents for that time, and, therefore, the charge made in New York is equivalent to 7½d. per B.T. unit. The average number of hours of lighting appears to be 2·4 per day per lamp. A record is kept of every lamp, so that the average life is known, and it comes out at about 477 hours.

The consumption of coal is ·82 lbs. per lamp-hour, and there are 5 lamps per horse-power, rather a low result, due probably to the inefficiency of the old system of conductors. The average number of lamps per subscriber

FIG. 3.



THREE-WIRE DISTRIBUTION SYSTEM.

is twenty-one, while the average amount paid annually by each subscriber is £40.

The difficulties that have occurred in practical working have arisen principally from a too free use of fuses, which have given much trouble by going when they ought not to go. The conductors have, unfortunately, been fitted with bad joints, and a good deal of annoyance has arisen from leaks in the mains; but all these effects are due to immature experience, and can readily be remedied in future extensions.

The distribution of the currents is carried out by a network system of double mains which involves the use of an immense weight of copper. Dr. Hopkinson in England, and Mr. Edison in America, have shown how an economy of 60 per cent. in the weight of copper used can be effected by using three wires and two dynamos. This system is shown in Fig. 3, and it is now invariably used by Mr. Edison.

The whole area of the portion of the city lighted by this system is about a quarter of a square mile, it covers fifty blocks of buildings and fifteen streets, and the capital invested is £200,000. It is intended to open two mo central stations, of much larger dimens

in the upper part of New York, and there is no doubt that with the experience gained, the troubles encountered in the old station will be remedied.

At Roselle—a small village in New Jersey—I saw an interesting installation. There 1,200 lamps were used, supplied by three dynamo machines joined up in series; the lamps also being worked in three series. Overhead wires were used, and the charge was 1 cent. per hour for each 10-candle lamp; this is equivalent to gas at 2·5 dollars per 1,000 cubic feet.

Another very interesting central station, wired up on the new 3-wire system, was established at Brockton, a town about seventeen miles from Boston. There were 2,090 lamps going, and 1,040 were about to be started. The station was installed in October, 1883, with 250 lamps, and the rate charged was 1 cent. per hour for each 10-candle lamp. There were 108 subscribers. The capital of this country is 100,000 dollars, 25 per cent. of which belongs to the parent company. The station has not yet earned a dividend, but the expenditure balances the receipts. The business is growing at such a rate, that there is no doubt that, at the end of the second year, a handsome balance will be realised. It is in the hands of a very earnest worker, Mr. W. Lloyd Garrison, who is determined to faithfully test the commercial value of the new illuminant.

I also inspected two large central stations in New York, worked on the Weston high tension system. One station worked 384 arc lamps, while the other was working 500 arcs and 1,750 glow lamps. All the details of these two stations manifested the same mechanical skill and solid appearance that I have already alluded to as indicative of the Weston system.

In no instance could I perceive sufficient appreciation given to the value of a renewal fund to provide for depreciation. Some estimated the proper allowance for depreciation as low as 2½ per cent., and others at 5 per cent., but in no case did anybody exceed the latter figure. It is very questionable whether this is sufficient to allow for the decay and deterioration of electrical plant, especially of the conductors, which form such a very heavy item in the expenditure in England. I scarcely think less than 7½ per cent. should be allowed.

Conductors.—In all cases throughout the whole of the States, with the exception of the Edison system, the conductors are invariably aërial wires, generally of copper, protected to a certain extent with cotton or hemp covering, and supported by poles fixed along the kerbs of the streets. The high tension currents are always used, and up to the present moment the freedom from danger has been very marked. A considerable amount of trouble has been caused to the telegraph and telephone companies, by these powerful electric light currents finding their way into the telephone and telegraph circuits by contacts. I traced no less than seven fires in offices which were undoubtedly due to these causes.

The Edison Company have not yet established a central station in Chicago. The chief reason adduced for this is that they have not been able to obtain the consent of the Town Council to place their wires underground, although this same Town Council has ordered all the telegraph and telephone wires to be put underground.

Secondary Batteries.—The use of secondary bateries has not received so much attention in the States as on this side of the water. The form most generally in use is that of Mr. Brush, which is a modification of the Planté cells, and is said to give very good results. Another modified Planté I saw in use at Philadelphia, made by Dr. Starr. The positive plates were composed of a solid frame of lead, filled with thin inverted V plates arranged "herring-bone" fashion, the interstices between which were filled with fine lead shavings. These plates are specially prepared by some process that I did not learn, so as to save the time lost in preparing them as required by the Planté method. The experiments that have been made with the Faure secondary battery were not well spoken of.

Instruments for Measuring Purposes.—The point connected with electric lighting to which I devoted a considerable amount of attention, was the practical working of Edison's method of measuring the current used, by the electrolytic action of a small portion of the current upon two zinc electrodes immersed in a solution of sulphate of zinc.

In all the central station systems based on the Edison arrangement, this mode of measuring is adopted, and it is said to give reliable results. The measurements are undoubtedly based on accurate formulæ, and if all the conditions are fulfilled, the results must be perfectly true. The method is scientifically and is accurate, based on the system used to standardise all current measurers.

The bottles containing the solution and the zinc electrodes are collected every month, and, in the Edison district of New York, two men are employed whose sole duty it is to collect and measure these "meters." Each meter contains two bottles. The plate which has suffered loss of zinc is removed from each bottle, dried, and carefully weighed. The mean between the two measurements is taken as the true one, and the weight of zinc lost, in milligrammes, multiplied by a co-efficient, gives the number of dollars to be charged for the light consumed during the month. The charge made to the consumer, though based on the current supplied, is really charged on the light given, and it is 1 dollar per 1,000 candle-hours. The weight of zinc lost is made equivalent to so many candle-hours, and the subscribers, therefore, pay for the light they receive and not for the current they use.

There are 1,160 bottles out, fifty of which are measured every day. No trouble whatever is experienced in measuring them, and they are unquestionably accurate within 1 per cent., which is more accurate than any existing gas meter. When a meter is taken away for measurement, it is immediately replaced by another one, so that there is no break in the record should consumption be going on. The charges to the consumers are based on these measurements. The consumers themselves have taken various steps to check the reliability of the meter returns, and the result has been that the public has gained confidence in the accuracy of the measurements and the charges made.

Electric Lighting of Ships.

The electric light has been applied to a great extent to the lighting of ships. The great ferry boats of the Pennsylvania Railroad, are so lighted. Those magnificent hotel steamers that ply between New York and Fall River; and those on Lake Superior, as well as those on the Mississippi and other large rivers, are either wholly illuminated, or are gradually being fitted for that purpose. The fittings on such a steamer as the *Bristol* are very complete, and were carried out by the Edison Company. Special engine rooms are provided for the electric light machinery, and the fittings throughout contain all the most recent improvements, and form a very admirable installation. Many of the great passenger steamers crossing the Atlantic are being fitted, and the comfort to passengers in consequence is inestimable.

General Commercial Position.

The problem as to whether electric lighting is practical, and as to whether that means of illumination can be made to pay, has been thoroughly solved in the United States. The great mistake that has been made there, as it has been made heie, has been the attempt to enter into competition with gas. The Edison Company started on the basis of the charges made for gas, and the result of the two years' working has been to show that this was a financial mistake. Electricity must earn its future success entirely upon its merits and not on its economy. In the case of street lighting it has proved itself to be a good thing, and if once a thing is proved to be good in America, it is immediately taken up. "Progress," in that country, is the word. Novelty is a certain criterion for consideration. Manufacturers do not hesitate to clear out their entire factory, if they find that they can get cheaper and better work by entire renewal. So with the electric light. If it proves itself (as it unquestionably does) to be a better light than gas, then gas-fittings will be instantly removed, and electric light fittings substituted, without particular reference to the cost, so long as it is reasonable and within the means of the consumer.

I have said, more than once, that at the present day we can only regard the electric light in England as a luxury, and we must pay for it as a luxury. But there is no reason why it should always remain a luxury. There are various chances of economy which justify the conclusion that, sooner or later, the price will be brought down so as to relieve us of the use of the term luxury as applied to it. For instance, the output of the dynamo can be extended, as has already been done with several types, particularly, as I have pointed out, in the case of the Brush pattern, where 60 arc lamps are now lighted where only 40 lamps were supplied by the earlier and unimproved machine.

Again, considerable reduction in the weight, and therefore in the cost, of the conductors has been obtained by the production of the 3-wire system. Moreover, when existing patent rights lapse, the manufacture of dynamos will become general, and the consequent competition will, no doubt, result in the production of efficient machines at a sum far below the cost of those made under existing patent rights.

The efficiency of the glow lamps has also

been very considerably affected by the improvements made, for instance, by Messrs. Woodhouse and Rawson, and by Mr. Bernstein. The efficiency of the Edison lamps means the consumption of energy at the rate of 5 watts per candle, but lamps are now being made which give an efficiency of 2·5 watts per candle, with an equal life, which is equivalent to an immediate reduction of 50 per cent. in the amount of energy required to maintain the system alight, and, therefore, in the cost of its production.

There is still vast room for economy, and it is quite clear that the prices which are now necessary to make electric lighting pay, must not be regarded as final; they will be brought down.

Even now it is possible, in England, to make a system pay at the rate of a halfpenny per glow-lamp per hour; and no one who has ever experienced the charm and comfort of the electric light, and who has electricity brought to his door, and supplied to him at this rate, would hesitate to pay that figure for the use of electric lamps, although he could obtain the same light by gas at less than half the price.

There is a point that will lead to the introduction of the electric light that is very marked in the United States, viz., its influence, when applied to the streets, upon the morality and safety of the public.

The Chief of the Police of New York has gone so far as to say that "every electric light erected means a policeman removed." This, though probably not true as regards actual numbers, is so far true in fact, that the supervision of the streets and thoroughfares is rendered far simpler when they are brilliantly illuminated by the electric light. Its moral effect is principally to be noticed by the way in which it has checked the formation of crowds, and disturbed the haunts of those who, unfortunately, infest most great towns and cities, and who render the streets of London at night a disgrace to modern civilisation.

DISCUSSION.

Admiral Sir E. OMMANNEY asked if Mr. Preece would describe the lighting of Madison-square, New York?

Mr. PREECE said this square, which was about the size of St. James's-square, was lit up by one of the tall masts he had described, 200 feet high, having a circle round the top of eight Brush lamps. The effect was very good, the whole square being brilliantly illuminated, the outline of the shrubs and trees being very distinct. It was, however, hardly necessary to describe it, as the same thing was to be seen at the Health Exhibition.

Mr. CROMPTON said he was not able to go to America this year, but he had had much pleasure in interviewing some of the gentlemen when they came back, and had tried to find out the various points in which our American cousins were ahead of us in electric lighting. It was difficult to add anything to what Mr. Preece had stated, for he had pointed out very fully all the causes which had led to the great development of electric lighting in America. One of these was the lawless manner in which overhead wires were carried about all over the towns, a system which was utterly impossible here, so that arc lighting in England had to be confined to isolated installations. The high tension system of lighting was comparatively easy to work out, and if there were equal facilities here, probably as much would have been accomplished as in America. It was true that the Americans had so much greater faith in the new illuminant, that large capital had been put in Mr. Edison's hands, and thus he had been able to carry out a large experiment in New York, from which valuable lessons could be learned, such as only could be learned from working on a large scale with a central station. The main points to be noticed were the success of the meters, and the general success in keeping the lights going continuously. But when you came to details of lamps and dynamos, the Americans were not ahead, but somewhat behind ourselves. The invention of tamidine by Mr. Weston was nothing new; it was simply dried cellulose, which Mr. Swan, Mr. Crookes, and others had used almost from the commencement; the only new thing seemed to be the zigzag shape of the filament; and to call this a new invention reminded him of what was said to have been done in the way of inventing a new dynamo, viz., taking some one else's, and painting it a different colour. Mr. Preece said the glow lamps were not to be compared in efficiency with those of Rawson and Woodhouse; and other information he had himself received confirmed that view. Some very interesting figures had been given with regard to the consumption of coal to produce a certain quantity of light; they certainly gave a higher efficiency to the performance of the Edison dynamos and lamps in New York than he had obtained from other quarters, but even taking those figures, they gave the coal used per candle at ·052 lbs., whereas in this country the average number of large installations gave ·021 lbs. The difference was due to three causes; 1st, the much higher efficiency of the compound steam-engines now used in England; 2nd, the greater efficiency of the dynamo used here; and 3rd, the extra efficiency of the Swan lamps as compared with the Edison. It had nothing to do with the price of coal, as he

had worked it out entirely by reference to the weight. Mr. Weston's dynamo only followed the same lines on which Dr. Hopkinson, himself, and others had been working for some time past. The electromotive force, in volts, per ohm of resistance of the armature was not so high in America as has been obtained in this country by Dr. Hopkinson and himself, and he believed also by the Ferranti and Gordon alternating machines. He could not agree with Mr. Preece that there was much reduction to be looked for in the cost of the machines; there was already so much competition in the manufacture, that many had been compelled to retire from the field; but there was considerable economy to be hoped for when the light became general, and when all the accessories and small fittings became articles of common manufacture. The dynamo was spoken of as if it formed the most expensive portion of the plant, but it was not so. In an installation costing £1,000, very often the dynamo and steam-engine together only came to £250 or £280, the remainder being made up of the extremely high cost of engineering, having to send a highly-paid man a long distance, and his being often kept waiting about many days, on a job which could only be compared with one on which a gasfitter at 30s. a week would be employed. It was this which made electric lighting so costly on a small scale.

Mr. SELLON said the question of secondary batteries had been alluded to, but in his opinion it was so important that he should prefer reserving any remarks upon it until another occasion, when it might form the principal topic of the discussion.

Prof. G. FORBES said he felt, when going over part of the same ground as Mr. Preece, that he was learning something at every step; many of his old prejudices had disappeared, and he had determined to try and convince others of the error of some of the opinions held here. The subject had been divided naturally into the two branches of incandescent and arc lighting. He agreed with Mr. Preece that in this country we were far ahead of the Americans in incandescent lighting, especially in the lamps, though they had more experience in lighting from central stations. The general result was that in England the life of a lamp was at least twice as long as in America, and the cost of working for the same candle power about one-half. The Americans must have full credit, however, not only for their practical work with regard to central stations, but also for the thorough way in which they had laid out their plans theoretically for working those stations. He had never yet seen in this country a specification or estimate for an installation which was complete and satisfactory in its mode of distributing the potential about the district; and the more he thought of it, the more he was driven to the conclusion that the most sound and practical arrangement was the one introduced by Mr. Edison in New York. He did not allude to the three wire system, which was a mere matter of detail, but to the distributing boxes with feeding mains going to them, and with telegraph wires coming back to the engine-room, stating what was the potential at these different points, so that it could be regulated as required. The Americans were entitled to full credit for this beautiful system. With reference to the meters, Mr. Preece said he found that they worked very satisfactorily in New York, and he had given a most wonderful confirmation of that—an instance in which, after a month's working with four lamps, the time of which was carefully counted, there was only a difference of two lamp hours. This was a far greater degree of accuracy than could have been anticipated or was given by any gas meter, and he wished he could have the same confidence in the method, but the information he had received had not been so satisfactory. One person told him that when the bill came in at the end of the first month, he was so aghast at its dimensions that he complained of it, as it was several times the cost of gas, and the examiner of meters agreed with him that he should pay what the gas had cost him previously. That was an easy way of settling the matter, but did not seem to support the character of the meter. Again, he carefully examined the arrangements in the *New York Times* office, and when he came to the crucial question of the cost, he was informed that they were to get the same light as before, and pay the same as they had paid for gas. With regard to arc lighting, he had learned a good deal in America. After the dynamo machine was first introduced by Gramme, it was considered a very important point to have a large number of sections in the commutator, and it had always been considered here, that the introduction of a large number was one of the greatest improvements; but in America they had gone on a totally different tack, and had reduced the sections to the smallest possible number. It must be very astonishing to Englishmen to find such efficiency attained on this plan. Another point on which they were conspicuous was in the regulation of the current over large districts, which they had attained by their greater experience, arising from the much greater facilities which they possessed. Experience in England showed that, especially when using small currents, there was great difficulty in regulating the strength. It seemed to be in a position of unstable equilibrium, so that the slightest change in the resistence of the lamps altered the current considerably. To meet this difficulty, the Americans had introduced regulators, the Thomson and Houston system using double regulators to increase the sensitiveness, by which means the current was maintained constant, whatever the number of lamps which were put in or out of circuit. Another reason why the system was so largely adopted in America, was that they were allowed to use overhead wires, and it was on this point that his opinions had changed. Many

had looked on high potential machines as being dangerous, and on overhead wires as being both dangerous and unsightly. It was undoubtedly true that high tension machines were more dangerous than low, but yet the number of fatal accidents in America, with 90,000 lamps, had been fewer even than in this country; this being due to the careful way in which the wires were insulated, and the installation carried out. As to the unsightliness of the wires he could only say, having spent most of his time in Philadelphia, that though they looked unsightly at first that feeling soon wore off, and by the time he left he looked upon them as being not at all objectionable, and he should not now object to see them in London. He could not help thinking that when the great advantages of the electric light, so desirable in the interests of the public safety and morality, were considered, the objection to the use of high potentials would be waived.

Mr. HAMMOND said it was not his privilege to go to Ameriea with the British Association, but he was there last year, and did not keep so much to the east as Mr. Preece had done. After leaving Chicago, he again found the electric light at Denver, in Colorado, in Salt Lake City, and in San Francisco, where he found, perhaps, the finest hotel in the world lighted throughout by electricity. The Americans, therefore, had gone much farther ahead than we had, but it was very desirable to draw the correct lessons from what was to be seen there. They were sometimes told that the English were very slow, but it was not entirely due to want of enterprise that in this matter we were behind the States. One great point was the price of gas, which was much dearer in America than in England. Again, many of these contracts in America, though they might not involve any loss, did not show any profit. In order to get sole control of a town, the municipality had in some way to be aceommodated, and this was done by supplying them with the electric light at 50 cents per night; but it would not pay even here to supply an arc light of 2,000 candles at £35 per annum; at any rate if you did not lose, you would make nothing by it. There were many cases where the price was double and treble, and where good profits were being made, but it was in localities like Salt Lake City, where people had plenty of money to spend, and where gas was about 17s. a thousand, that the best place for the electrical engineer was to be found. In some places in the west they had no light at all, and would have given anything for the electric light. Again, the Americans were very enterprising in business; they worshipped the almighty dollar, and looked upon the electric light as a good advertisement. A man would, for the sake of outshining his rival, put the most flickering arc light outside his door, and his experience was that the American arc lights were far behind our own. Again, the heat there was very great, and whilst in England some people liked the warmth of gas, in America no one would go to an hotel not lighted by electricity, if there were one opposite which was. It was, however, used simply for business, and was an advertisement. The man who would have it in his store would not think of using it at home to make it more comfortable, because it cost too much. Gradually, however, some of the leading Americans were introducing it for domestic purposes; but when he was in New York, Mr. Edison had not got it in his new house, and Mr. Brush had not got it in his in Cleveland. It was remarkable to see the effect the overhead wires had had on Professor Forbes. An Englishman in New York would think London a peaceful village in comparison. There was a railway overhead, the passengers on which could converse with the people at the first floor windows along the route, and there were these posts with 60 and 70 wires on them all along the principal streets; in Fifth Avenue they were worse than anywhere. He did not mind them himself, but they must not regard this matter simply from the point of view of those who lived by electric lighting, and he was sure such things would not be tolerated in England. There was no Board of Trade in America, but he was sure they would find it better eventually to put the wires underground, when the system was firmly established. But directly they wanted to put them underground in England, they had to apply to Parliament for permission; in America it was only necessary to find out the man who represented the municipality, and the matter was easily arranged over a long drink at the bar. That was local option; but in England they had to go to Parliament. As they urged on Mr. Chamberlain the other day, why should not the local authorities be empowered to grant liberty to any company, in whom they had confidence, to put wires underground? It was a mere accident of their industry that they had to deliver electricity by wires; if they could deliver it like other wares, by van, they would not need to ask Parliament anything about it; but because they had to use wires, a delay of some eighteen months, and all kinds of difficulties stood in their way. The great lesson to be learned from America was that it could be done. There were hundreds and thousands of people ready to pay double the price of gas for the electric light, but capitalists were constantly saying they were told it could not be done. Mr. Edison had shown in New York that incandescent lighting could be supplied from a central station, and that when done on a large scale, the risk of failure was infinitesimal. In New York they were able to make a small margin of 3 per cent., using 5 watts per candle, getting 7s. 9d. for it, and paying 3-4ths for the manufacture. In England it could be produced with 3 watts per candle, at a cost for manufacture of 3s. 8d., instead of 6s. All the installations in America had been made in one way, taking the current direct into the houses. A reference had been made to storage batteries, but in no case had they yet been used as a part of a general system, as we hoped would soon be intro-

duced in London, and with a much less capital outlay. If in New York they could make 3 per cent. on a capital of £200,000, which included an immense amount sunk in experiments, they might hope, in England, to make 8 per cent. on a capital of £70,000, which would be sufficient, with proper plant, and the advantage of further experience; and by working at three-fifths the cost, they might even hope to make 12 per cent.

The CHAIRMAN said no one had referred, except the last speaker incidentally, to what was the great obstacle to the progress of electric lighting in England, viz., that owing to the wires having to be put under the streets, the belief being entertained (though that was a moot point) that the local authorities had no power to grant permission for this, and that Parliament had to be applied to. Mr. Hammond had spoken as if the only objection to this was the delay and expense in obtaining the Act, and why he and every other speaker had refrained from touching on what was the real obstacle he did not know, but it was a pity to close the discussion without reminding the meeting of what it was that really prevented electric lighting from central stations being carried out in England. It was not simply that an Act of Parliament had to be obtained, but that when obtained it would be unfair, because it would have to be in accordance with a general Act which must have been passed with the express intention of forbidding the progress of electric lighting. Imagine a new steam-boat company being started in Liverpool, which would have to use the docks, and assume that these docks belonged to the corporation, and that to be allowed to use them it was necessary to obtain an Act of Parliament, and that the condition of its being allowed to use the docks was that at the end of twenty years if the company paid a dividend, the corporation should be entitled to purchase the undertaking for the value of the old materials, but if the company did not pay, the corporation should not be obliged to purchase. He said that this appeared to his hearers to be ridiculous; but why was it more ridiculous in connection with a steam-boat company than in connection with the distribution of electricity? It was a mere accident that they had to go to Parliament; it was because they required to lay the wires under the streets in the same way as gas companies required to lay gas-pipes. When the Electric Lighting Act was in the House of Commons, the Board of Trade tried to say that at the end of 15 years the local authority in whose district the wires were laid should have the option of purchasing the undertaking, not for what it had cost, but on the then value of the material for their purpose. All apparatus put down in process of developing, which had been removed to make way for better, would not be reckoned as one shilling in the valuation. When the Bill got into the House of Lords, an effort was made to improve it, but the utmost concession obtained was to increase the 15 years to 21; and thus it stands, that, at the end of that time the company, if the venture paid, must submit to be bought out at the value of the old materials. If it did not pay, no one would care to take it; but the company might go on until they had worked the affair up to a profit, not for their own benefit, but for that of the local authority, for after the first option of purchase, at the end of every five years in perpetuity the option re-arose, and might be exercised to purchase the property for the value of the old materials. Such a monstrous proposition was never heard of. The other way of acquiring property for public purposes was well known, and the public took advantage of it, when it was to their interest. The bridges over the Thames were acquired by the Metropolitan Board of Works when none of the original shareholders were getting a fair dividend, and then the principle of valuation was that of a capitalisation of the net profits made. In this way Waterloo-bridge, which was now as good as the day it was built, and which could not be reproduced, without the approaches, for £750,000, was acquired for about £475,000. No one could object to a valuation based on the capitalisation of profits, if you were to have compulsory powers at all, because it was the true mode of valuing property; but that principle was entirely departed from in the case of electric lighting. Why? Was it a non-meritorious industry, or was it offensive in any way? No; the reason was that gas-lighting had, in many cases, got into the hands of corporations and local boards, and they, having become traders with public money—which, according to the canons of political economy, it was not expedient they should be—they found themselves liable to competition by something better. Thereupon a Bill was passed whereby electric lighting from central sources was strangled. What reasonable man would embark his capital for a twenty-one years' enjoyment of a new industry which you had to educate people to support, and where you had gas being constantly reduced in price. The metropolitan gas companies most properly worked under a sliding scale, whereby, if they reduced the price 1d. per 1,000 ft., they might increase the dividend ¼ per cent.; while, on the other hand, if the price were increased 1d. the dividend was diminished in the same ratio of ¼ per cent. The result was, the gas companies were stimulated to do their best, and the price was constantly reduced. It was said the other day that the monstrous condition he had mentioned was not a novelty, that a similar one prevailed in the case of tramways; but in the Tramways Act there was the reservation that the local authority should not work the tramways and take the fares, but should let them out on lease; thus, they had not the incentive of making profits by trading to improve compulsory purchase. No such restrictions were introduced into the Electric Lighting Act. He asked for no Government aid or favour for the new industry, but simply for fair dealing, and to let alone one of the most meritorious applications of

science to the ordinary purposes of life, one that effected the solution of a problem which only a few years ago was declared to be insolvable—the division of the electric light in lamps supplied from a central source, and he did wish that such an industry as this should not be absolutely forbidden by an Act of this character. Further undulatings, such as the supply of gas, of water, or of electricity, were progressive; you started with a certain number of customers, and required a capital of, say, £20,000. The customers in the district gradually increased, and more capital would be wanted say at the end of five years; how were you to get it? If you tried to issue new shares, people would naturally say—"There are only sixteen years of your term remaining, and it is not worth our while to go into it." And if the company issued £100 shares, and only called up £20 at first, what right would it have at the end of 15 years to call up another £20, when there were only six years left in which to make it profitable. The whole thing was absolutely unworkable. Had there been any serious intention to promote electric lighting by this Act, it would have been better considered, but the evident intention was to stop it, and nothing but a strong expression of public opinion would get it reversed. When the Bill was passing through the committee, he sent a letter to the newspapers, headed, "Something more than an Electric Lighting Bill," in which he pointed out that it introduced a new and vicious principle of turning local authorities into traders, and that it would not stop there, and it had not. The Corporation of Birmingham was applied to, to allow pipes to be laid down for conveying air under pressure for working small engines in factories. which was a healthy and useful mode of supplying power. His opinion on the scheme was asked by the Corporation, and he advised on various engineering details; when the Bill was drafted, he asked to see a copy, and to his astonishment found a clause that at the end of 21 years the Corporation were entitled to purchase the whole thing, not on the profits, but for the value of the materials "as a going concern," those words not being included in the Electric Lighting Act. Again, an application had been made this year for a bill referring to the distribution of water under pressure, in another town, and there again the same provision was inserted. The thing was growing, and if people did not come to their senses, and teach the Government that it was not the business of imperial or local government bodies to become traders, it would go on until all the business of bakers, butchers, shoemakers, and everything else would be in the hands of the mayor and corporation. He was sorry to have occupied so much time, but this matter really lay at the root of the want of progress in electric lighting. There were numbers of houses at the West-end where people would not burn gas in their sitting-rooms—he would not for one—and where they would willingly pay double the cost of candles or lamps for electric light. No one who had once enjoyed the comfort of this light, unless he were in dire need, would abandon it for a cheaper illuminant, until something better, as well as cheaper, was invented. He would conclude by moving a hearty vote of thanks to Mr. Preece.

The vote of thanks having been carried unanimously,

Mr. PREECE said he had not much to reply to, and he was pleased to find that the paper had not elicited much opposition. First, with regard to overhead wires he would say that if he were to live 50 years in Philadelphia he should never become satisfied with these overhead wires. They were hideous in the extreme, and the only advantage he had found for them was that they afforded a welcome shade from the fierce glare of the sun. But it was not necessary to go to America for them; in Brighton they were carried overhead, though not in the unsightly fashion which so disfigured the streets in the United States. In one place in New York he had counted 144 wires on one post, and in Broadway there were six distinct lines of posts going down the street, there being thirty-two separate companies in that city carrying wires on poles. There was no necessity for it at all, for it was found by the Post-office that, whenever the number of wires through a town exceeded fifteen, it was cheaper to put them underground than overhead; and he was quite certain that when the people in America came to their senses, this plan would be adopted. With regard to the meters, he thought the two cases Professor Forbes had referred to must have occurred in the early days of the opening of the central station. There was no doubt that in the first twelve months considerable difficulties were experienced in the use of the meters, but now they had become more familiar these difficulties were avoided, and the meters were certainly working well. Meters on the same principle were also in use at Brighton, where there was a central station serving a great many places with the electric light; it was done in spite of this wretched Act of Parliament, and even without the consent of the Local Board. A gentleman in the room who was somewhat imbued with the American spirit, Mr. Hammond, went to Brighton and established a central station, from which he supplied the Grand Hotel, the Orleans Club, and many other places, in spite of the objectionable Act of Parliament and the Local Board, and he used meters on the same principle, to regulate his charges.

Correspondence.

SMOKELESS HOUSES AND MANUFACTORIES.

Sir Frederick Abel, in his opening address, appears to look on the practical realisation of the economical

and smokeless use of fuel as yet in the dim future. He is, doubtless, as well acquainted as any living authority with the possibilities of gaseous fuel, but does not appear to be very sanguine of its general adoption by those to whom we owe our present smoke polluted atmosphere.

I have never joined in the present agitation for smoke abatement, for the simple reason that I have no faith in the present method of advocating it. I think I may claim, without egotism, to know something of the subject in some of its bearings, and in calling attention to the practical results obtained in my premises, I do not claim to have done anything wonderful, or to have made any brilliant discovery. As a matter of fact, I do not consider that any "brilliant discovery" is necessary for the realisation of a very great part of the programme of the advocates of smoke abatement, the means adopted being both rough, simple, and cheap. In my own house we have remaining one coal fire, which is occasionally used, but which will shortly be, like all the rest, done away with. We have fourteen rooms, with hothouse and conservatory, and have used four tons of coal in two years; we shall probably not use one ton in the next twenty years, and we adopt the system we use because it pays and is convenient.

At the works, where we employ between 120 and 130 hands, using an ordinary steam boiler with engine, two blacksmiths' fires and sixteen burners' stoves, smoke is never seen, except for a few minutes when fires are being lighted; and to those who are sufficiently interested, I am prepared to demonstrate beyond question that smokelessness and economy, both in labour and fuel, may go together without any great expense or preparation in any way. The Society has done me the honour to award me the Siemens gold medal for the best application of gas to heating and cooking in dwellings; if they will offer another prize for smokeless works and dwellings, the cost to compare favourably with those of the smoke-producing order, I will at once put in my claim for it, based on the results of the last twelve months or more.

THOS. FLETCHER.

Warrington,
November 28, 1884.

SANITATION IN JAPAN.

Will you allow me, as one who has been resident in Japan for ten years, in Government employ, and who has had probably as great facilities as any one for becoming acquainted with Japanese construction in every part of the country, to express my astonishment at the remarks made by Mr. Ernest Hart, as given in last week's *Journal*, relative to the efficiency of Japanese houses in regard to scientific sanitation? He states that, in that country, an Asiatic civilisation will be found in immediate contact with the last results of European scientific knowledge and practice, and speaks of the rapidity with which the Japanese people have mastered the principles and practice of scientific sanitation.

The capabilities of the Japanese gentlemen who represented their country at the Health Exhibition which Mr. Hart describes, I do not desire to touch on; but I am personally acquainted with what has been practically accomplished in Japan, up to within the last few years, in house construction, and I have little hesitation in declaring that there has been no house erected in any part of Japan which illustrates, in any degree whatever any principle of scientific sanitation. There is a complete and entire absence of drainage throughout the country, excepting the drainage works in Yokohama, which I myself carried out for the Government. There is, with few exceptions, no system of heating, except by boxes of charcoal placed in the rooms, or by American stoves, having light iron pipes led through the wooden walls of the building, and causing innumerable fires. Ventilation is hardly necessary, as the wind blows in volumes through the ill-fitting carpenters' work of the paper screens, or of the more modern doors and windows.

The following, extracted from a paper which I had the honour of reading before the Asiatic Society of Japan, is an accurate description of the modern Japanese house:—

"The foundations consist of a stone wall generally about 8 inches thick and 2 feet high. On this wall is laid a wooden sole plate which is about 6 inches square, and into which the wooden uprights forming the walls of the house are morticed. The uprights, which are also about 6 inches square, are placed from 2 to 3 feet apart, so that when they are still uncovered they appear like a forest of posts. There are very thin laths placed longitudinally along the uprights at distances of 6 feet or so apart, which are secured to them by wooden pins. Diagonal struts or ties are very seldom used, and the stability of the building is, therefore, dependent on the stiffness of the different joints in the framework, assisted by the nails used in the different parts of the erection. The roof is formed of timbers very much larger than is required for strength, and is laid with mud and tiles. Inside, the houses are generally lined with planks about ⅜ in. thick, on which wall paper is placed, the ceilings of the rooms being executed in the same way. In some of the better class of houses, however, the walls and ceilings are lathed and plastered, but this is by no means general. Outside the walls there are sometimes fixed laths to which square tiles are nailed—the joints of the tiles being pointed with plaster—sometimes the walls are plastered without any tiles, and in those houses which are intended to be of the best description thin stone flags, of a thickness of about 4 to 8 inches, are built on one another, and kept in their places by small iron dogs attached to the woodwork. In some of the houses iron stove pipes are let through the walls surrounded

by a stone, but the more pretentious have fireplaces and chimneys erected with stone in their interiors. These are generally about 5 or 6 feet square at the base, are generally badly built, and as they project through the roofs they must be in some cases 30 or 40 feet high. They can only be kept upright by the floor or roof beams which project against them, and are a constant source of dread and danger."

This description applies to houses erected generally in Japan, by the Japanese themselves. I am aware of a few public buildings, erected for them by English architects, of a somewhat better character.

There is nothing which Japan shows such utter neglect of as a proper system of house construction; this being generally supposed to be due to the periodical recurrence of severe earthquakes. But if the Japanese are told that they "have mastered the principles and practice of scientific sanitation," all attempts to instil new ideas, or to root out old notions, will become abortive.

For ten years my entire efforts were directed towards such objects, viz., the introduction into the country of the true principles of construction; and I have a lively knowledge of how these were being continually thwarted by the ill-timed, ill-considered flattery of far distant and necessarily superficial observers, who had never had the opportunity of studying the people at home.

With many highly excellent and unique characteristics, it should not be forgotten that the Japanese are a strangely self-sufficient and highly conceited people, and are generally contented with a mere superficial acquaintance with things.

R. Henry Brunton, M.Inst.C.E.,
Late Engineer-in-Chief to the Lighthouse Dept. of the Government of Japan.

162, Norwood-road,
Lower Norwood, S.E.,
December 1, 1884.

General Notes.

Antwerp International Exhibition, 1885.—Mr. E. A. Grattan, H.B.M.'s Consul at Antwerp, has been appointed British Commissioner for the International Exhibition, which is to be held at Antwerp next year, and Mr. P. L. Simmonds has been appointed by the Executive Council of the Exhibition at Antwerp their Agent-General for Great Britain and Ireland. The President of the Exhibition is H.R.H. the Count of Flanders, and the Vice-President, the Minister of Agriculture, Industry, and Commerce. The office of the Agent-General is at 35, Queen Victoria-street, and communications from intending exhibitors should be addressed to him there. Announcement has been made that a Fine Arts' Exhibition will be held at Antwerp next year, at the same time as the Industrial Exhibition.

Cultivation of China Grass in Brazil.—According to the *Central Blatt für Textil Industrie*, the industrial energy now being developed in Brazil is accompanied by various projects of interest to China grass consumers. A concession has been granted to a German resident, by which various rights as to the treatment of the fibre are secured to him for a lengthened period. The researches of various scientific authorities have resulted in the climatic advantages of Brazil being fully established with reference to China grass cultivation. The hope is expressed that the German mercantile community will unite in this object by forming an association, and thus acquiring a position compensating them for that which North America has gained by the prospective arrangements for growing China grass in the Southern States.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at Eight o'clock:—

December 10.—"The Preparation of Butterine." By Anton Jurgens. Professor Odling, M.B., F.R.S., will preside.

December 17.—"Present and Prospective Sources of the Timber Supplies of Great Britain." By P. L. Simmonds. Sir Charles Tupper, K.C.M.G., C.B., High Commissioner for Canada, will preside.

At the meetings after Christmas, the following Papers (among others) will be read.

"The Employment of Hydraulic Machinery in Engineering Workshops." By Ralph H. Tweddell.

"The History and Manufacture of Playing Cards." By George Clulow.

"The Musical Scales of Various Nations." By A. J. Ellis, B.A., F.R.S.

"A Marine Laboratory as a means of Improving Sea Fisheries." By Prof. E. Ray Lankester, M.A., F.R.S.

"Labour and Wages in the United States." By D. Pidgeon.

"Recent Improvements in Coast Signals." By Sir J. N. Douglass.

"The Influence of Civilisation upon Eyesight." By R. Brudenell Carter, F.R.C.S.

"The Evolution of Machines." By Prof. H. S. Hele Shaw.

"Tempered Glass." By Frederick Siemens.

"The American Oil and Gas Fields." By Professor James Dewar, F.R.S.

"Past and Present Methods of Supplying Steam Boilers with Water." By W. D. Scott Moncrieff, M.Inst. C.E.

Howard Lectures.

Thursday evenings at Eight o'clock.

A special Course will be delivered under the

Howard Trust, on "The Conversion of Heat into Useful Work." By W. ANDERSON, M.Inst.C.E.

LECTURE III. DECEMBER 11.—Molecule Theory of Gases. Laws of Volume, Pressure, and Temperature. Isothermal and Adiabatic Lines of Permanent Gases and of Vapours. Joule's equivalent. The doctrines of Carnot. The Limits of Efficiency of Heat-engines.

LECTURE IV. JANUARY 22.—The working substances in Heat-engines. Gunpowder Gases. Coal Gas. Hot Air. Steam. The method and cost of preparing the working substances. The theoretical Calorific Power of Fuels, the Degree of Efficiency to be expected, and the Efficiency actually realised.

LECTURE V. JANUARY 29.—The Discharge of Artillery; Work done on the Projectile, and on the Gun and Carriage; Limits of Efficiency. Gas-engines; Nature of their Action, Mechanical details, Limits of Efficiency, Results actually obtained.

LECTURE VI. FEBRUARY 5.—Hot Air-engines; Nature of their Action, Mechanical details, Limits of Efficiency. Compressed Air Refrigerating Machines. The Steam-engine, Non-condensing, Condensing, and Compound; Nature of its Action, Mechanical details, Limits of Efficiency, Results actually obtained.

CANTOR LECTURES.

Monday Evenings at Eight o'clock. The First Course will be on "The Use of Coal Gas." By HAROLD B. DIXON, M.A.

LECTURE II. DEC. 8.—Coal Gas as a source of Light.

LECTURE III. DEC. 15.—Coal Gas as a source of Heat.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DEC. 8...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Harold B. Dixon, "The Use of Coal Gas." (Lecture II.)
Farmers' Club, Inns of Court Hotel, Holborn, W.C., 5 p.m. Mr. J. Howard, "Farm Rents: Past, Present, and Future."
Surveyors, 12, Great George-street, S.W., 8 p.m. 1. Discussion on Mr. Shaw's paper. 2. Mr. E Smyth, "The Arithmetic of Compensation for Agricultural Drainage."
Geographical, University of London, Burlington-gardens, W., 8½ p.m. General J. T. Walker, "Four Years' Journeyings through Great Tibet, by one of the Trans-Himalayan Explorers of the Survey of India."
Medical, 11, Chandos-street, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 5 p.m. Mr. F. Gale, "Newspapers from the time of the Commonwealth onwards."
Inventors' Institute, 4, St. Martin's-place, W.C., 8 p.m.

TUESDAY, DEC. 9...Farmers' Club, Inns of Court Hotel, 4 p.m. Annual General Meeting.
Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.
Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussions on papers by (1.) the Hon. R.C. Parsons, "The Working of Tramways by Steam." (2.) Mr. W. Shellshear, "The Sydney Steam Tramways."
Pathological, 53, Berners-street, Oxford-street, W. 8½ p.m.
Photographic, 5a, Pall-mall East, S.W. 8 p.m.
Anthropological, 3, Hanover-square, W., 8 p.m. 1. Sir John Lubbock, "Marriage Customs and Relationships among the Australian Aborigines." 2. Mr. A. W. Howitt, "The Jeraeil, or Initiation Ceremonies of the Kurnai Tribe."
Colonial Inst., Westminster-palace Hotel, S.W., 8 p.m. Mr. G. Baden-Powell, "National Unity."

WEDNESDAY, DEC. 10...SOCIETY OF ARTS, John street, Adelphi, W.C., 8 p.m. Mr. Anton Jurgens, "The Preparation of Butterine."
Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.
Geological, Burlington-house, W., 8 p.m.
Graphic, University College, W.C., 8 p.m.
Microscopical, King's College, W.C., 8 p.m. 1. Mr F. R. Cheshire, "Some New Points in the Anatomy of the Bee." Mr. G. F. Dowdeswell, "Variations in the Development of a Saccharoaryces."
Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.
Sanitary Assurance Association, 74A, Margaret-street, W., 7½ p m. Mr. Mark H. Judge, "Public and Private Responsibility in Sanitary Matters."

THURSDAY, DEC. 11 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Howard Lectures.) Mr. W. Anderson, "The Conversion of Heat into Useful Work." (Lecture III.)
Royal, Burlington-house, W., 4½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 7 p.m. Mr. C. Armbruster, "The Dramas of Richard Wagner."
Parkes Museum of Hygiene, 74A, Margaret-street, 4½ p.m. Free Popular Lectures on Precautions against Cholera. Mr. Shirley Murphy, "Local Precautions, Duty of Sanitary Authorities in Town and Country, and of the Householder."
8 p.m. Mr. W. Eassie, "The Systems of Treating Water on Basements for draw-off and other upstairs purposes."
Telegraph-Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. 1. Annual General Meeting. 2. Mr. W. H. Preece, "Electricity in America, 1884."
Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, DEC. 12 ... Astronomical, Burlington-house, W., 8 p.m.
Quekett Microscopical Club, University College, W.C., 8 p.m.
Clinical, 53, Berners-street, W., 8½ p.m.
New Shakspere, University College, W.C., 8 p.m. Miss Leigh-Noel, "Shakspere Garden of Girls, III., Wild Flowers—Perdita, Miranda," &c.

SATURDAY, DEC. 13...Physical, Science Schools, South Kensington, S.W., 3 p.m. 1. Prof. A. W. Reinold and Prof. A. W. Rücker, "The Effect of an Electrical Current on the Rate of Thinning of a Liquid Film." 2. Mr. Herbert Tomlinson, "A Theory of the Molecular Architecture of Solids, illustrated by a Wire Vibrating Torsionally."
Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

CORRECTION.—In the last number, p. 54, col. 2, line 7, for £3 *read* 3d., line 24, for this *read* their.

Journal of the Society of Arts.

No. 1,673. Vol. XXXIII.

FRIDAY, DECEMBER 12, 1884.

All communications for the Society should be addressed to Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

The usual short course of lectures, adapted for a juvenile audience, will be given on Wednesday evenings, December 31st, 1884, and January 7th, 1885, by Professor J. Norman Lockyer, F.R.S., on "Universal Time: our Future Clocks and Watches." The lectures will commence at seven o'clock. Nearly all the tickets having now been disposed of, the issne will be stopped on Monday next, December 15. As all the available accommodation will be required for those members who have applied for tickets, it will be understood that no member can be admitted without a ticket.

DR. RICHARDSON'S LECTURE.

A lecture on "The Painless Extinction of Life in the Lower Animals," will be delivered by B. W. Richardson, M.A., M.D., F.R.S., on Tuesday afternoon, December 16th, at 4 p.m. Members can introduce two friends personally, or by ticket.

FOTHERGILL PRIZE.

In addition to the prizes announced in the *Journal* of October 31, the Council have awarded the Gold Medal, offered under the Fothergill Trust, to Messrs. Chubb and Son's Lock and Safe Company, for the best exhibit in Class 27 of the International Health Exhibition.

FOREIGN & COLONIAL SECTION.

A meeting of the Committee of this Section was held on Thursday, 4th inst., at 4.30. Present:—Mr. Hyde Clarke in the chair, Mr. B. F. Cobb, Admiral Sir Erasmus Ommanney, F.R.S., Mr. Trelawney Saunders, Mr. P. L. Simmonds, Mr. J. A. Youl, C.M.G., with Mr. H. Trueman Wood, and Dr. Mann, Secretary of the Section. A list of papers proposed for reading during the present Session was discussed and agreed to. Particulars will be announced in due course.

HOWARD LECTURES.

The Second Lecture of the special course delivered under the Howard Trust, on "The Conversion of Heat into Useful Work," was given by Mr. W. Anderson, M.Inst.C.E., on Thursday evening, December 4th.

CANTOR LECTURES.

On Monday evening, December 8th, Mr. Harold B. Dixon, M.A., delivered the second lecture of his course on the "Use of Coal Gas as a Source of Light."

PRIZES FOR ESSAYS.

The Council of the Society of Arts have had placed at their disposal by Mr. William Westgarth, a member of the Society, a sum of £1,200, to be awarded in prizes for essays on "Dwellings for the Poor," and on the "Reconstruction of Central London."

The first prize will be a sum of £250 for the best practical essay upon the re-housing of the poorer classes, and especially of the very poorest classes, of the metropolis.

The second prize will be a sum of £500 for the best practical essay upon the whole subject of the sanitation, street re-alignment, and reconstruction of the central part of London.

In addition to the above, there will be three further prizes of £150 each:—1. For the best treatment of the engineering considerations. 2. For the best treatment of the architectural considerations. 3. For the best treatment of the sanitary considerations. Any of all of these last-named prizes may be awarded to the same essay as that to which the £500 prize may be awarded, or they may be awarded separately.

The essays must be sent in to the Secretary of the Society of Arts, not later than December 31, 1884. No essays can be received in manuscript.

The name of the writer must not appear on the essay, but each essay must have written or printed thereon a motto, and be accompanied by a sealed envelope, containing on the outside the same motto, and within the name and address of the writer.

The Council reserve the right of withholding any of the prizes, or of awarding the amounts, or parts of the amounts, in any manner which may seem to them desirable. They also reserve the right of publishing any essay to which a prize may be awarded.

Further particulars can be obtained on application to the Secretary, John-street, Adelphi.

Proceedings of the Society.

FOURTH ORDINARY MEETING.

Wednesday, December 10, 1884; Prof. W. ODLING, M.B., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Carswell, John George, 37, Victoria-road, Old Charlton, Kent.
Fisher, Alfred, School of Art, Gosport, Hants.
Gavey, John, Post-office Telegraphs, Cardiff.
Lopes, George, B.A., London, Brighton, and South Coast Railway, London-bridge, S.E.
Lynch, Edward James, Rio de Janeiro.
Meade, Thomas de Courcy, Hornsey Local Board, Southwood-lane, Highgate, N.
Slagg, Charles, Presteign, Radnor.

The following candidates were balloted for and duly elected members of the Society:—

Bagot, Alan Charles, Royal Hotel, Torquay.
Baker, Benjamin, 2, Queen-square-place, Westminster, S.W.
Donaldson, George, 6, Bedford-square, W.C.
Hewitt, Daniel Hewson, 27, Stanwick-road, West Kensington, S.W.
Pye, James, Clovelly-house, Eversley-park, Chester.
Varley, Cromwell Oliver, Cromwell-house, Adelaide-road, Brockley, S.E.
Vine, J. R. Somers, 27, Great Winchester-st., E.C.
Waterhouse, Edwin, 13, Hyde-park-street, W.
Watson, Gerald Thomas, 131, Holland-road, Kensington, W.
Wheeler, George Robert Welby, Town Hall, Caxton-street, Westminster, S.W.
Worton, John, Blaenavon, Monmouthshire.

The paper read was—

BUTTERINE, OR OLEOMARGARINE BUTTER.

By ANTON JURGENS.

If it should be considered that an apology is needed for presenting to your consideration this evening a few remarks upon the subject of the commodity known as butterine, or oleomargarine butter, I might find one in a remark of Sir Frederick Bramwell, a past Chairman of your Council, who, in his address at the opening of the Session of your Society in 1881, said that the process of extraction (of this substance) "is an extremely interesting one; and the product appears to me to be as free from objection as would be the butter itself that is made from cream in the usual way."

I venture, moreover, to think that the present is a fitting time to make some inquiry into the particulars relating to this article, and that such an inquiry is indeed needed, owing to the attention which has been recently drawn to it, and to the many exaggerated and false reports which have been circulated as to the materials from which it is produced.

To make the truth respecting it more widely known, and to present facts capable of proof to the attention of your honourable Society, is the object I have in view; and it is with the assurance that inquiry can only be beneficial to the future of a legitimate and useful product, that this paper is submitted.

In referring as I have done to the remarks of Sir Frederick Bramwell, I do not forget or overlook the fact that, in the address to which I have alluded, and notwithstanding his remarks on the interesting nature of the manufacture of oleomargarine, he stated that he personally preferred "less scientific butter," and no one can quarrel with him for so doing; indeed, it may be stated, with all candour, that it is not pretended that butterine does, or ever can, take the place of the best fresh butter.

This well-known delicacy and article of food, highly appreciated by those who are fortunate enough to be in a position to obtain it from the private dairies of themselves or friends, or through rare good chance from the butter merchant, will always stand unrivalled; but its very delicacy is one great cause of its being particularly liable to become rancid. It is almost impossible, except under very favourable conditions, to keep fresh butter for more than a fortnight at the very longest, the compound and delicate substances, known to chemists as butyrin, to which butter, when fresh, owes its flavour, being extremely volatile and liable to produce rancidity owing to the tendency of these substances to rapid change and decomposition. We do, however, assert that for all cooking purposes butterine is, in every respect, fully equal to real butter, and is quite as wholesome and nutritious.

In Holland, where small quantities of butter are made by cottagers who own, perhaps, one or two cows, it is often found that this butter is of so poor a quality and so rancid, owing to the long time that elapses before it is brought to market, that the wholesale merchant who buys it up is obliged to have it washed and re-churned before it is fit for sale or export.

In the United Kingdom the demand for edible fats is so large, that pure butter cannot be produced in quantities nearly sufficient to meet the requirements of the consumers. It is not possible to estimate with precision the quantity of butter made in the United Kingdom, yet some idea may be gained by the following attempt :—

In the year 1883, there were, according to the "Abstracts of Agricultural Returns," about 3,400,000 cows giving milk in the United Kingdom, producing at a rough estimate about 1,800,000,000 gallons of milk. In making this estimate of the quantity of milk produced, I have taken the annual yield of milk per head of cows, &c., to be 500 gallons. It may be interesting to mention that, as far as it is possible to ascertain, the annual yield of milk by each cow in the—

	Galls. milk.	Capable of yielding butter.
United Kingdom	503	201 lbs.
Normandy	748	299 ,,
Britanny	343	171 ,,
Holland	814	270 ,,

After making allowance for the milk used at once as milk, say five-twelfths, or about 775,000,000 gallons, and three-twelfths, or about 465,000,000 gallons, for cheesemaking, there are about 620,000,000 gallons remaining for the production of butter, which, at the rate of 1 lb. per $2\frac{1}{2}$ gallons, the recognised standard, would yield about 248,000,000 lbs.

Estimating the consumption of butter and substitutes for butter at the low average of 4 ozs. per week, or 13 lbs. per annum per head of the population of about 35,000,000, you have a consumption of about 455,000,000 lbs., and if you had to rely on butter alone there would be a deficiency of upwards of 207,000,000 lbs. Those whose circumstances enable them to pay from 1s. 6d. to 2s. per lb. for butter, are to a large extent unaffected by this deficiency; but it must be borne in mind that the consumption of fat is a physical necessity, and this need is as great, or greater, with the poorer and labouring community, who form the largest portion of the population. Therefore, as sufficient butter is not and cannot be supplied recourse has for many years past been made to other means of supply, and a survey of the poorer neighbourhoods reveals the fact, that fats and dripping (more or less pure and palatable) are eagerly sought, and a high price paid for them, to meet the requirement.

To obviate the necessity of eating dry bread (a necessity specially distasteful to children) immense quantities of low-class jams, syrups, treacle, &c., are consumed, none of which possess a tithe of the value of butterine. It is to meet this positive want of a good substitute for butter, that butterine has been introduced. It is claimed for it, that it provides at a very moderate price, an excellent and nutritious food; the consumption of which already proves that it is highly appreciated by those for whom it was mainly intended. But as has been found previously, in analogous cases, the cupidity of some retailers has been aroused by the similarity of the article to pure butter, and they have sought to increase their gains by selling butterine at the price of butter; although themselves buying it from the manufacturer for what it is, at a fair price. This, upon discovery, has brought the commodity itself into undeserved discredit. When sold, as it is by many, as butterine at the price of butterine, it commands a ready sale and is well appreciated.

Butterine, manufactured as will presently be described, cannot be distinguished from butter, except by the most careful analysis, and, in point of fact, we have had some of our butterine analysed by the most eminent analysts, who have failed to discover any difference. A care-ful analysis of butter and of butterine, respectively, demonstrates that, for all practical purposes of nutrition, their composition is identical.

There are two advantages possessed by butterine over butter that are undeniable, and admitted by those who have studied the subject, viz. :—

1st. Butterine is much cheaper.

2nd. Owing to its composition, butterine does not become rancid, but retains its sweetness for a much longer time than butter. This is owing, as before stated, to the absence of butyrin, the constituents of which impart the delicate aroma to fresh butter, but by decomposition, cause it soon to become rank.

Besides these advantages, which butter has not, butterine in some points closely resembles true butter; thus, it is palatable, it is wholesome, and it is nutritious.

With these few introductory remarks, I will

now proceed to describe the mode of producing the material to which I am directing your attention, premising first that it is not in any true sense an "artificial butter."

Some years ago, it is true, the celebrated chemist, M. Mège-Mouriés, thought he had discovered a means of artificially producing real butter, and that almost without the aid of a cow. Having proved, or at least satisfied himself, that milk, which contains the constituents of butter, is in itself the result of re-absorbing fat under the action of gastric juice, he took fat as it comes from the animal when killed; he warmed it up to the natural temperature of the animal, he extracted the portion that became liquid at that temperature, and then treated this with gastric juice, which gastric juice he proposed to obtain from the stomachs of sheep. He then churned the product, as milk is churned, and in the result he had a substance which he believed to be butter; but M. Mège was aware that even if this product was a true butter, it was a comparatively tasteless one, and to produce his best result, he was obliged, after all, to have recourse to the cow, though not to a live one; for to impart to his artificial butter the delicacy of flavour of true butter, he proposed to mix with it small portions of ground up cow's udder.

These ideas of M. Mège, however good in theory, were not found to be capable of being worked in a practicable manner, because, even if M. Mège was correct in his theory—which may be doubted—the difficulties of manufacture were insuperable, and the product, when completed, cost more than real butter, so that, as a commercial undertaking, it could not possibly succeed.

I do not myself pretend to be able to show you how to make real butter, except by the churning of cream or milk, but butterine, as manufactured at our factories at Oss, in Holland, is composed of oleomargarine, milk, the purest vegetable oil that can be obtained, and real butter.

Oleomargarine, the chief constituent, is prepared as follows. From the freshly slaughtered carcases of cattle in the abattoirs of large cities, the superfluous portions of suet are taken, and carted in vans, specially fitted, to the factories of manufacturers of repute, where the fat is carefully sorted, and the very finest, cleanest, and sweetest portions selected for the manufacture of oleomargarine.

Fat forms about one-twentieth of the weight of a healthy animal; only a small portion of this can be consumed as food in the ordinary way; the rest used to find its way to the tallow melter.

I claim that it is a matter of no small importance that we are enabled by our process to produce, at a moderate price, an abundant supply of wholesome food, and, at the same time, to utilise a very large proportion of a previously almost waste material.

But to attain a satisfactory result, the greatest care and attention must be used to select only those pieces of fat which are perfectly sweet; the smallest quantity of tainted fat would contaminate the whole mass, would render it useless for our purpose, and entail serious loss upon the manufacturer. The fat, when selected, is passed into a machine which reduces it to a pulp about the consistency of real cream. Thus brought to an even texture, the fat is now put into wooden vats and heated by steam or hot water at a moderate temperature, not too hot, because too high a degree of heat imparts to the fat a flavour of roasting, and detracts seriously from its value as a substitute for butter. When melted, the fat is run into jacketted vats to cool and slowly clarify. After some hours the stearine, or harder portion, begins to solidify, its white colour contrasting conspicuously with the bright yellow of the oleo. When the material has acquired sufficient consistency, it is wrapped, in small quantities, in clean white cloths, and subjected to hydraulic pressure of about 100 tons, in order that as much as possible of the oleo should be extracted. The stearine still finds its way to the tallow melter, and is utilised in the manufacture of candles, night lights, &c., but the pure oleo is destined for a better application.

Thus we have traced oleomargarine from its origin; we shall have to follow it packed in large casks to our manufactory at Oss, where it is to be made into butterine, but before doing so, we may pause to consider the importance and extent of this industry.

There is one firm in London which is able to turn out from ten to twenty tons of this valuable oleo per week; from our factories we send an average of 150 tons per week of oleomargarine butter to England alone.

In the manufacture we employ an average of 10,000 gallons of milk per week, which is supplied to us by the farmers of the district, who find it more profitable to sell the milk to us than to make small quantities of inferior butter, as heretofore; butter that was known in the trade by the term, not, I believe, very euphonious to English ears, "Bosh," but

when spelt as we spell it, with a "c" before the final "h," it is harmless and necessary, and meaning only "a wood." The term is derived from the district around us, "Hertzogenbosch, a ducal forest," or, in French, "Bois-le-Duc." These words have long lost their original meanings, and are now only the names of a town and a district which has been named after it. This district formerly produced a large quantity of low class butter, which came to be known by an abreviation of the name of the locality where it was made; thus, when butterine displaced it, it was an easy matter to transfer the name to its successful rival.

But to follow the oleomargarine, and to resume our explanation of the further stages of the manufacture into butterine:—The oleomargarine, with a proportion of butter and milk, and with the finest and sweetest vegetable oil, are churned together for some time, after which the churned mixture is cooled by coming into contact with ice-cold water, and is then passed between large fluted rollers, during which process a proportion of salt is incorporated with it. It is delivered by these rollers on to a large table on rollers, which passes it on to the packers, who in turn pack it into quantities according to the requirements of the trade, and the manufacture is completed and the product is then ready for sale.

The butterine, thus completed and ready for consumption, is now very similar to butter in appearance, taste, and the purposes to which it is applicable, the real distinction and the only distinction being that it does not possess the delicate flavour the best newly-made fresh butter has; but for all purposes of cookery it is as good as the best butter, and, as before stated, it keeps longer, and supplies a want severely felt by those to whom the price of fresh butter renders it an article of diet rarely if ever to be had.

It will be evident from the above description of the manufacture, that the most perfect cleanliness is absolutely essential in every part of the operation, and indeed it is a matter of the greatest moment to the manufacturer to keep up the quality and reputation of his brand, which is put upon every package of his production. An inferior article would soon bring him into disrepute.

Oleomargarine, treated in the manner described, differs very little from the fat which forms the cream in milk from which butter is churned, except that in the case of oleomargarine, the fat is taken direct from the animal, the stearine being extracted by pressure, while in the case of natural butter, the fat is converted by the action of the mammary tissues of the cow into cream, which being churned, the fatty matters are recovered in the form of butter.

All admit the satisfaction of partaking of the luscious fat so conspicuous in the "Roast Beef of Old England," and a moment's reflection will convince all, even the most sceptical, that the same fat must be equally nutritious under its altered form as when smoking upon your tables at the hour which I have experienced is turned to so good an account in English homes.

From the particulars already given, you will have gathered that this new utilisation of what was formerly, to a great extent, an inferior product, viz., the excess fat of cattle, and its application to a much higher purpose than before, gives employment to a large number of persons, and, in point of fact, the production of butterine has become a legitimate and extensive industry affecting the welfare of whole districts in Holland and elsewhere, providing a fresh outlet for the produce of multitudes of small farmers, and affording the means of support to many thousands.

Some idea of the magnitude of the trade, and the interests involved, may be gathered from the fact that during the year 1883, the total export of butterine, from Holland alone, was estimated at 38,000 tons to 40,000 tons, representing a nett value of about £2,802,500 to £2,950,000.

A question affecting the welfare of so many of our fellow beings cannot be dealt with without due consideration of their right to be heard, and their interests protected, and its being admitted that some regulation of this new industry is desirable, in the interests of all concerned, it becomes a question how such regulation may be applied, so as to fairly maintain the rights of all.

It was not to be expected that such a business could develop without causing opposition of various kinds; such may be classed, generally, under two heads—(1st) that of commercial opponents; and (2nd) the prejudice of the unthinking, aroused by sensational articles in the public press, and by exaggerated reports.

There is no doubt that the first mentioned is really the least, although it might, under most circumstances, have been the keenest; but as already shown, the small farmers and cottagers who, prior to this manufacture, made small quantities of inferior quality butter, have now an outlet at their doors for all the milk they can provide, while those who formerly con-

ducted the trade in butter find the business in butterine no less profitable.

The second class of opposition is that which requires more consideration, being of a character that only accurate knowledge of the subject can dispel. The proverb, "Give a dog a bad name and hang him," is well known, and doubtless many useful inventions and applications have been condemned by that stubborn enemy "prejudice," because they had not friends, or power sufficient to resist its attacks.

In the case of oleomargarine butter, all manner of false and highly-coloured statements have been set afloat by interested parties, through the public press and other channels, respecting its composition. These have caused all manner of suspicions to harass the mind of the public; and the few instances of a bad article being sold have been so used, as to asperse the character of the whole trade.

The absurdity of such procedure will be apparent to those who bestow a moment's thought to the subject; as well might we condemn every butcher as a cheat because occasionally one with no reputation to lose is charged with selling bad meat.

At the same time, while deprecating such a line of wholesale condemnation, it is felt by those who are carrying on this manufacture in a straightforward manner, that it is one in which deception may be practised, and in their own interests they would hail with satisfaction any regulations which should compel traders, whether wholesale or retail, to call things by their right names, and secure the consumer protection from the fear of unwholesome mixtures.

If the retailers, instead of pretending that a mixture of butter and butterine is butter, would sell the butterine by that name, by which it is now well-known, or would sell it by the name of oleomargarine butter, they would enhance the value of a good commodity, remove the odour of suspicion and distrust which clings to it, and would make it unprofitable for any to produce a bad article.

The true position that butterine should occupy was well appreciated at the recent International Health Exhibition. In a paper read by Dr. James Bell, F.R.S., on the 14th July last, he said:—

"Butterine and oleomargarine are, in the opinion of high authorities, legitimate articles of commerce, if sold under names which properly indicate their origin and composition; and if manufactured in a cleanly manner, from sound fats, are perfectly wholesome, and afford the poor a cheap and useful substitute for butter, especially during the winter months, when good butter is both scarce and dear."

Mr. C. E. Cassall, on October 28th, in the last of the interesting demonstrations on the analysis of milk and butter, which have been given in the hygienic laboratory of the International Health Exhibition, referring to oleomargarine, said:—

"That manufacture, if properly carried out, produced a very satisfactory article of food, which could not be objected to, except that the manufacturers had no business to sell it as butter. There was no danger in oleomargarine, and it might be freely admitted into the market when it came from the factories where it was produced on a large scale, because carefulness as to what was used, and cleanliness, were particularly looked to in the various processes."

The *Lancet*, of July 26th, 1884, says:—

"Butterine is better and cheaper than much of the common butter sold."

You will perhaps allow me before I conclude, and with a view of enforcing upon you the importance of the subject which I have brought under your notice this evening, to call attention to some figures drawn from the Board of Trade Returns, showing the extent of the trade in butter and butterine, and the dependance of England upon foreign sources for the supply of these necessaries.

In the year 1863, twenty years ago, the imports of butter and butterine into England were 968,000 cwt., of the value of £4,537,000; in 1873, these figures had risen to 1,279,000 cwt., of the value of £6,955,000; and at the date of the last return they had amounted for last year to 2,334,000 cwt. of the value for the year of £11,773,000.

England only imports five articles which, taking the test of value, are more important than butter and butterine; the order in which they stand is as follows:—

IMPORTS, 1883.

1	Cotton	£45,000,000	sterling.
2	Wheat	31,000,000	,,
3	Wool	25,000,000	,,
4	Sugar	25,000,000	,,
5	Flour	12,000,000	,,
6	Butter and butterine	12,000,000	,,

You will observe from these figures that the imports of butter (including butterine) stands sixth in importance on the list, and that the value of the imports amounted last year to no less a sum than £11,700,000.

I am glad to have had this opportunity of making these few observations. I feel assured that nothing but good can come out of a candid and impartial examination of a subject hitherto veiled in unnecessary obscurity.

The policy of "live and let live" should be applied to this as to every other legitimate business, and although local interests and prejudices may attempt, for a time, to prohibit new departures, it is not, I believe, the custom in England to uphold present modes, to the total prohibition of new and beneficial discoveries.

I have thus, gentlemen, endeavoured to present, to you briefly, some facts and considerations relative to a branch of industry not of very great age, viz.:—The manufacture of butterine or oleomargarine butter, and thank you heartily for having allowed me to lay these observations before you.

DISCUSSION.

Prof. REDWOOD said this subject was of very great importance, and from the manner in which the paper had been received, he had no doubt there was a general feeling in favour of the object aimed at, viz., to produce a good, wholesome, and tolerably cheap substitute for an article which was daily becoming more expensive, and would, but for the introduction of butterine, have become already a very costly article indeed. Viewing the matter in the abstract, simply as a question how far oleomargarine or butterine was a good and suitable article of diet, the use of which might be freely encouraged, he had no hesitation in expressing his opinion as highly favourable to it. Some years ago, he had the advantage of visiting Mr. Jurgens's factory, and had seen the whole process, both there and elsewhere, and he then formed the opinion that the article produced was of the most unexceptionable character. But then he had to view the question not only from this point of view, but in his position as a public analyst he had to consider the circumstances under which it was supplied to the public, and he often, in his official position, had to condemn it, not because he did not approve of the article itself, but because of the circumstances under which it was sold. He constantly had to analyse samples of what was sold as butter, but which proved to be simply butterine. His objection, therefore, was to its being sold under a false name, and he should condemn anything sold as butter which was not really such, and which, as Mr. Jurgens candidly said, was not equal to the best description of butter. As was the case with butter, so with its substitute; there was good butterine and bad, and his advice to the public was, that every one should exercise his own judgment in selecting what best suited the purpose for which he wanted it.

Mr. OTTO HEHNER said there could be no doubt about the ability and eloquence with which Mr. Jurgens had set forth his case, but he must entirely differ from his conclusions. The question of substitutes for articles of food was a very difficult one; and he was not satisfied that any such substitutes were legitimate. He doubted if chicory was a legitimate substitute for coffee, for it had absolutely none of the qualities of coffee, but there was a large consumption of it. With regard to this substitute for butter, was it sold as butter or was it not? Mr. Jurgens said a few unscrupulous men sold it as butter, but as a public analyst he should say that very few people sold it as butterine; it was nearly always sold as butter, and herein lay the great evil. If it were sold under its true colours, it was a legitimate article of food, but the temptation was exceedingly strong to sell it as butter. In fact, it was prepared and put up with the view, not only that it should be a nourishing article of food, but that it should be an imitation of butter. Why was that? There was no need for it. Oleomargarine, as it came from the press, was as nourishing, in fact, more so, than as it was sold. Why was it mixed with milk and a little butter except to mislead the public? Then came the question how far this could be a substitute for butter; in what did it resemble it? Anyone listening to the paper would gather the impression that this was practically butter, except for a little butyric acid. He asserted, on the other hand, that it only resembled butter in its consistency; in every other respect it was totally unlike it. Butter had an absolutely unique composition amongst fats, and there was no other analogous to it. It was very easily saponified, and saponification being one of the processes of digestion, it was, therefore, easily digested, far easier than any other fat with the exception of cod liver oil. That was one of its great advantages, and it could be absorbed in almost unlimited quantity. No one ever felt sick from eating butter, but you might feel very sick from eating any other fat. In articles of food the effect should be looked to, not the physical resemblance. Some authorities said there was hardly any difference; in fact, M. Mège had attempted to make ordinary fat into butter. It was said what difference could there be between cow's or ox fat taken from one place and taken from another. All the difference in the world. The ordinary fat was deposited in the body from the carbo-hydrates, or the fat which the animal took in its food, but butter was not so formed; it was conclusively proved that every fat granule in milk was due to the decomposition of protoplasm in the cells of the udder. Every animal which secreted milk secreted butter of the same composition, so far as they had been examined. There was only one vegetable fat which at all resembled it, viz, cocoanut oil, and that had lately been attempted to be used as a substitute for ordinary butter fat, but

it was essentially different, and could never be a real substitute. No serious attempt had really been made to produce butter fat, which must be from the conversion of nitrogenous matter, not by making ordinary fat look like it. You could press the stearine out and use it for candles, but the remainder was not butter. Nor was it correct to say that fat was a waste product; it had always been most valuable. Suet was an expensive article of food, and why need you press it into butterine? You had just as much food in the pure fat taken from the animal, as when you made it into butterine. In an article of food one must not regard the composition only, but the flavour, and butter had a distinct flavour of its own, which could not be imitated. It was for this flavour the consumer paid. Why was a bottle of wine worth 6s.? Not for the alcohol or the acidity, or the water in it, but for the small quantity of flavouring material. The same with tea; sloe leaves had exactly the same nourishing properties, but not the aroma. Large quantities of artificial wine were manufactured, and Hambro' sherry could be bought at 3¼d. a bottle, but it was never sold to the public as such, but always as genuine wine; and the argument always was that the natural produce was not sufficient to meet the demand; and thus fraud was justified. Admitting that butterine, as such, was a legitimate article, seeing the great facilities it afforded for fraud, he thought it ought to be prohibited, in the same way as the manufacture of burglars' tools. It was not illegal to make a "jemmy," but it was likely to be used for an illegal purpose, and he looked upon butterine in the same light.

Mr. CARPMAEL said he had not looked upon this compound for some months past with any such disfavour as the last speaker, who seemed to be a purist of the first water, and who even proposed to prohibit the manufacture of "jemmies." How could you open packing cases without them? He really did not know where they should get to, if such kind of legislation were seriously advocated; that because a thing might be turned to an improper use, therefore the person who made it should be treated as a felon, and his manufacture summarily put an end to. Mr. Jurgens had proved to his satisfaction that this product resembled butter in many, if not in all its qualities. He never said it was as good as butter, but he said—You cannot give the poor butter, but I give them the next best thing, and why should he not? He wanted it sold under its true name; but the last speaker said other people sold it as butter, and therefore the maker and seller should all be treated alike, as scoundrels, and the trade stopped. Then it was said that this material was no better than plain suet. He was not a chemist, but he could not agree with that statement. He should not like to eat a slice of bread with a piece of cold suet on it, but he constantly ate a piece of bread with this fat spread on it, when genuine butter could not be had, which it often could not. It was palatable and wholesome, and made a piece of bread go down better than it would with a slice of cold suet on it. The Chairman of the Council, in his inaugural address, dealt with this subject, and said it was a wholesome article of food (and if it was wholesome, why should it not be made), and that it was a pity that it had been stigmatised in the press as a vile compound, prepared simply for purposes of deception. He perfectly agreed with Sir Frederick Abel in that view. When Mr. Jurgens asked him to visit his factory, he had a strong impression that he should not like the product. Years ago, he heard dreadful tales of fat being collected from the sides of sewers, and scraped off the banks of rivers, and mixed with ground flints and all sorts of things, which made one shudder, and even when butterine was first introduced, he heard nasty suggestions of blow-flies, gentles, and other horrors, so that he confessed that when he went to inspect the process he had a feeling that he had much better have kept away. However, he went, and though not a doctor or a chemist, there was one thing he could speak to, as well as anyone else, and that was the beautiful cleanliness of everything. The result of the first process was a beautiful clean looking grease, like that seen on the top of potted meats. Mr. Hehner asked why it should not be sold in that state, but why should it if you could make a better article by churning it up with milk. It was said the only object was to make it look a little more like butter, but if it tasted better, why should you not do it? Having seen the process in England, he went over to Mr. Jurgens' place in Holland, where he saw oleomargarine treated in the manner which had been described, everything being done in the most cleanly and beautiful way, the material being treated as daintily as cream in a dairy; and it seemed to him it would be monstrous to try to prevent the product from being sold. Having seen the whole process, he materially altered his preconceived opinion, and came home quite prepared to advise those who could not get butter to be content with butterine.

Mr. LIGGINS desired to draw attention to two points which had not yet been mentioned, viz., the retail price at which this compound could be sold to the public, and the question whether it was possible for analysts to detect it when mixed with butter. It would be very hard on the public if they had to pay the price of butter for an article which might only be worth 5d. or 6d. a pound. It ought to be sold only under its own name. He had seen the articles in the press to which reference had been made, and he believed the gentlemen of the press reported the facts as far as they could get at them, and the conclusion he came to was that butterine was of very little use except to adulterate butter, and to grease cart wheels. He was glad to hear more about it, but he still thought it a pity to use it for palming off on the poor a low-priced article under the name of a better.

Mr. HEHNER said there was no difficulty in distinguishing butterine from butter, either alone or in combination.

Mr. WILLIAM BOTLY thought it very appropriate that this subject should have been brought forward in Cattle Show week, when so many agriculturists were in town. This question was investigated by the Royal Commission on Agriculture some years ago, when the secretary of the Royal Agricultural Society visited not only Mr. Jurgens' manufactory but several others in France and America, and his report was published not only by the Royal Commission, but in the *Journal of the Royal Agricultural Society*, that report being decidedly favourable. The effect of the price of butter on the English dairy farmer was very serious, and last winter he was informed that had it not been for these substitutes, the price of good fresh butter would have been at least 2s. 6d. per lb. Good artificial butter was more palatable than bad real butter, and if sold for what it really was neither the farmer nor the consumer could complain. In fact, the report he referred to concluded by saying that the best description could hardly be distinguished from real butter.

Mr. GEORGE BARCLAY, knowing something of the trade in butterine in the north, had been delighted with the paper, for there was hardly any subject which more required elucidation, and it was evident that the public had been in total ignorance with regard to it. He could safely say that a greater boon had never been conferred on the poorer classes; though the denunciations of the press when it was first introduced had left a stigma upon it which had not yet been removed. All the manufacturing classes in Lancashire and Yorkshire liked it, and purchased it freely, but from the bad character given it by the press, they did not like to ask for it under its real name. The sooner this reproach could be removed from a valuable article, the better; and in his opinion, those who had introduced it were entitled to the thanks of the public. Mr. Hehner had spoken about the value of aroma, but he should like to know where a man with 18s. a week, and a wife and eight children, was to find the money to pay for the aroma of pure butter. He would be very glad to get 3 lbs. of butterine for 2s. instead of paying 5s., or more for butter with an aroma. Before butterine was introduced, large quantities of butter were imported from Ireland, and was often stored five or six months, until it became rancid, unpalatable, and unwholesome; but now this was not required. Much of the butter previously imported was far inferior to good butterine, and if the sale of this were prohibited, as some proposed, the price of butter would go up to three, four, or five shillings, and the working classes would never get it at all. From one end of the country to the other, analysts had pronounced it a pure and wholesome article, and its use was a benefit, not only to the working classes, but also to the higher classes.

Mr. M. S. S. DIPNALL said he was not a manufacturer or dealer in this article, nor to his knowledge a consumer; but it had always been a maxim of the Society of Arts to encourage the utilisation of waste products; and seeing the displacement of tallow by gas, mineral oils, and electricity, it seemed as if there was some room for the utilisation of surplus fat, of which so much had been said. If a wholesome article of food could be produced from it, why should it not, provided, of course, that it was sold under its proper name. They had not, however, heard the relative prices of the articles or their comparative nutritive values, save in a general way. He saw nothing wrong in mingling together various elements to make a wholesome food, and there had been no allegation that this was unwholesome, or that its introduction had done harm. Reference had been made to the interests of the agriculturists, but suet was an agricultural product as well as milk, and if the supply of milk were to be largely increased, there would also be an increase in the supply of suet. Any invention which tended to utilise as food an article which would otherwise be employed for inferior purposes, was for the public good, but it should be sold under its own name.

Mr. RENOUF suggested that manufacturers of butterine might protect themselves against fraudulent practices by retailers by colouring it with some innocuous matter.

The CHAIRMAN said he believed all would be unanimous in feeling that they owed a debt of gratitude to Mr. Jurgens for the able manner in which he had brought forward this subject, and for the clear and candid account he had given of the manufacture, and he would therefore propose a hearty vote of thanks to him. With regard to the nature of the manufacture itself, it would be difficult to persuade a majority of unprejudiced persons that what Mr. Jurgens had called luscious beef fat was unwholesome, and if so, it might be taken for granted that no par of that beef fat was unwholesome; and especially that the softest part, which was capable of being squeezed out of it, and brought into a condition in which it could be spread on bread, was not unwholesome. It was evident, therefore, that the wholesomeness of this article in the abstract could not be called in question. As to how far it was capable of being compared with real butter, was another question. Without having made direct investigation into the matter, he thought it might be presumed that the fat liberated by the cow for the nutrition of its young was upon the whole more likely to be digestible and nutritious than fat obtained from any other source; but, putting aside the question of relative merit, the conclusion must be come to that the softer part of luscious beef fat could not be otherwise than a wholesome and nutritious article of food. With reference to any novel and successful manufacture, the question natur-

ally arose, not how far it benefited the manufacturer, but how far it benefited the public. If it was successful, the presumption, at any rate, was that it achieved a certain amount of public good. In this particular case, however, they might go farther and say that a person who rescued an article from inferior uses, and contrived that it should be recognised as a desirable article of food, was really achieving some public good. There was no doubt that by the introduction of oleomargarine into the market you substituted for butter a large quantity of nutritious material which had cost the stockkeeper a great deal to produce, and rescued it from inferior uses. The principal questions with regard to any novel article of food would be as follows:—First, as to its economy, and there could be no doubt that by this means a large population were supplied with something like butter which they would otherwise never be able to obtain, and those who wished to have real butter were able to get it at a price which would be far exceeded if nothing else were available. He might say, as a physician, that fatty food was one of the most valuable of all, and that a deficiency of this element was one of the great evils from which children especially suffered. Therefore, anyone who supplied a wholesome palatable fatty food at a reasonable price, conferred a great good on the community; more especially on the underfed and upon the young. The next question would be, was it palatable and attractive? That point might be easily passed over. As to comparing it with the best real butter, it was out of the question; but although it was quite true that butterine could not compare in flavour with the best forms of real butter, it was equally certain that it very far surpassed the inferior qualities. The next question was, was it good, wholesome, and nutritious? And there could be no doubt that the answer must be in the affirmative. Mr. Hehner asked why they did not take the soft expressed fat, and sell it at once under the name of oleomargarine. The simple answer was, that although the flavour of butterine did not come up to the flavour of the best butter, nevertheless, it was *buttery*, and that there was a prejudice in favour of, or a liking for, butter; and that people would rather eat a soft fat spread on bread which had a flavour of butter, than eat the same thing if it had the flavour of suet or dripping. Messrs. Jurgens had not only succeeded in imparting somewhat of the flavour of butter to their product, but they had also imparted to it a peculiar texture—not exactly that of real butter, but far different from that of suet, dripping, or melted fat generally. The thirty-five millions of people in this country could not all live on the very best; the quantity of the very best, the finest flavoured and most delicate food of all kinds, was absolutely insufficient for all the people who had to be supplied, and the great mass must be content with that which was not of the most delicate flavour, and must be content if they were able to obtain that which was wholesome, palatable, and cheap. Any one who supplied them with that, although it might fall far short of what wealthier persons might obtain, conferred a real and substantial good on the community. With regard to the question of names, butterine or butter, although he should be one of the last to defend the sale, by anyone, of an article under one name, which was really another, still it must be remembered that the meaning of words varied from century to century, and from age to age. The name applied in one age to one product, being in a succeeding age applied to an entirely different product, which had in the process of evolution replaced the original article, more or less. But putting that aside, it must be taken for granted that the consumer, at any rate, would only call this article by one name. In his family, with his friends around him, he would only speak of butter. The true name, butterine, had been for some years past, and still was, under a certain amount of stigma, but gradually, no doubt, the intrinsic merits of the article would make itself felt, and would achieve for the name of butterine, at any rate among the working classes, a very high degree of popularity, and by degrees the prejudice would disappear. In holding these views he was in very good company, for there was scarcely any scientific man who had taken upon himself to investigate the subject, who had not expressed himself in more or less similar language. Sir Lyon Playfair, Sir Frederick Bramwell, and Sir Frederick Abel, gentlemen who were in no way interested in the manufacture, but looked upon it simply from the point of view of scientific men and political economists, had given the opinion that it was an article of which the manufacture should be largely encouraged, as conferring a great boon on the working population.

The vote of thanks was carried unanimously, and the meeting adjourned.

Miscellaneous.

THE INTERNATIONAL INVENTIONS EXHIBITION.

The Executive Council and Sub-committees of the Exhibition have been sitting at the Society of Arts, since the middle of October, and have made considerable progress with the arrangements.

The applications for space have now all been examined by Sub-Committees of the Council, and a selection has been made of the most promising. The number of applications has been so great that it has been decided to limit very strictly the admissions in those classes which may be considered to have been fully represented in the Exhibitions of the present and of the past year. The Council will, therefore,

be obliged to refuse many valuable exhibits in such classes as those relating to food, clothing, and building construction. It will even be a difficult matter to accommodate those which have been selected, and it is feared that the list will have to be still further reduced. As soon as possible, information will be sent to those who have applied for space; but the enormous number of applications, far in excess of what was expected, have made it impossible to do this up to the present.

The Guarantee Fund now amounts to £48,280, a sum considerably in excess of that subscribed for the Health Exhibition, or for the Fisheries, the amount for the former being £26,518, and that for the latter £26,656.

INTERNATIONAL HEALTH EXHIBITION.

London Water Supplies. By W. Stephen Mitchell.

For the purpose of illustrating how the large population of London is supplied with water, the eight London water companies acted in concert, and in a specially erected building in the grounds, named "The Water Pavilion," they each showed plans, tables, models, and samples of plant which, taken altogether, gave a wide range of information as to their intakes, settling beds, and modes of filtering (Kent excepted), methods for pumping to high level districts, their distributory systems, the districts they serve, the quantities they deliver, and analysis of the varying qualities of the waters, tabulated with the varying death-rate.

Further than this, they arranged groups of fountains in the basin facing the Albert statue, which have been illuminated by electric light from lamps with screens of colours changeable at will; and the rhythmical rising and falling of the columns, and spreading jets with their varying tints and constantly modulating form and denseness, giving in alternation rich tones to masses of water, and delicate shades to evanescent spray, have produced things of beauty which will, in many minds, remain "a joy for ever." While the many-coloured jets have shown what a range of symphonies may be composed in such a way, the central column has illustrated the practical point of the height to which water can be thrown in cases of fire. It is, however, with "the water pavilion" that this report has to deal.

The building is an octagon, every side thus affording equal space to each of the eight companies. Within the outer walls is an inner octagon floored with tesselated pavement, around a central basin in which are water plants, and a raised fountain from which the water drips. The four arches by which this inner octagon is reached have at their base white crystalline stone, with tufts of green growing between them, and the lofty dome which roofs the building has foliage on its girders, while above all is a loose screen to ward off the heat of the sun and afford shade.

The companies, in arranging this pavilion, have been mindful to impress on the weary visitor the refreshing effect of the sight and sound of dripping water, and on hot days it has been, without doubt, the most agreeable rest in the Exhibition.

Around this inner octagon there are, as wall decorations, pictures of the waterworks, the reservoirs, and settling beds, and below them are tables giving particulars of the extent of work each company is doing.

The "exhibits" are almost entirely in the space between the wall of the inner octagon and the outer wall of building, which space has been named the outer gallery, a name which will be adopted here.

On the sides of the four arches between this outer gallery and the inner octagon, are reproduced full-sized sections of the filter beds of each company, one, that adjoining the space allotted to the Kent Company, being blank, as the Kent Company, deriving its supplies from the chalk, does not filter. The sections are behind plate-glass, and thus a better notion of their construction can be gained from seeing these than from a visit to the works themselves.

While the technical and constructive illustrations in the outer gallery have an interest for those who have the practical management of waterworks, it is in these filter beds the interest of the consumer centres; it is on the efficiency of these, both in their principle of construction and of the fidelity of their maintenance, he has to depend for the restoration of the waters of the Thames and Lea, pure at the outset, but contaminated in their flow, to a condition in which he may with an approach to safety use them for dietetic purposes.

From the time when the quality of the Thames water for drinking and cooking purposes was first investigated by a Royal Commission in 1828—when the Commissioners reported it was excellent, "when free free from extraneous substances"—down to the present time, the purification of the waters has been recognised as of paramount importance, overriding all questions of cost, or even of quantity supplied. The terrible lessons of the cholera scourges of 1832, 1854, and 1868, forced this on men's unwilling attention, and begrudged payments for honest attempts to improve the supplies on one side, and parsimonious economy in outlay on the other, have been upbraided in no faltering tones by disease and death that an enlightened foresight might have prevented.

The sensible, not to say charitable, way of viewing the earlier disasters brought on the metropolis by the methods of the water companies is to recognise that they did not possess that enlightened foresight, because the medical profession itself did not possess it. The water companies were composed of business men who understood outlay and interest on capital expended. Not a voice was raised against their meeting the growing

needs of the capital for water by taking it from the Thames or Lea, because no one was in a position to foretell what was coming. When the water companies began their work, the Thames was a fairly pure source of supply, safer, surely, than the wells of London, sunk in soil gradually sodden by overflowing cesspools. The water-closet was not invented. It was not till 1810 it was devised, and not till 1830 it came into anything like general use.

London wanted water. The companies supplied it, and London leaned on the companies for its supply. There was then no Hugh Myddelton to carry out supplies from a distance; pumping by steam-power had recently become general, and the Thames flowing past almost the doors of consumers, seemed to be able to supply all that was wanted.

The following Table will show how the Thames and its tributaries were first used:—

Table showing the Commencement of the Supply of Thames Water for Domestic Use.

Company founded.	Name.	From Thames in	From Thames Tributaries.	Change to Thames.	Above Teddington.
1723	Chelsea........	Chelsea Reach..			By the Act of 1852 [15 and 16 Vic. cap. 84], all the companies were required to move their intakes above Teddington, three years, and in the case of Chelsea, four years, being allowed for alteration.
1785	Lambeth	Charing Cross...			
*1805	Vauxhall		Effra	—? Vauxhall-bridge	
1806	West Middlesex	Hammersmith...			
1806	East London ...		Lea.................	Supplemented by Thames	
1811	Grand Junction		Colne and Brent	1820. Chelsea Hospital	

* The Southwark Company drawing from London-bridge was amalgamated with the Vauxhall in 1822.

Note.—In Wilson's "Life of Cavendish," p. 210, it is stated that the Rathbone-place water was, about 1766, pumped for use of neighbourhood.

When, however, the water-closets of the metropolis contaminated the waters of the Chelsea and Charing-cross reaches, from which supplies were drawn; when the water-closet ceased to be a fashionable novelty in Richmond, Windsor, Reading, Oxford, and other large towns on the Thames, then the troubles in earnest began, and what we now glibly talk of in chemical circles as "previous sewage contamination," to be detected by some form of much discussed chemical analysis, commenced to be a fearful reality. Whether the water-closet, like a particular form of fire-place, would be only a passing fashion, could not be predicted, except perhaps by cynical philosophers. For man to get rid of his own troubles by thoughtlessly increasing the troubles of others is said to be human nature, and the personal comfort secured might have been reckoned on for its continuance. History shows it was continued, and history, part of which we are still making, shows the troubles which people, acting as we still do, have brought on the metropolis.

This unexpected evil the companies of the past had to face, and here may be a convenient place to mention that some of the companies show relics of the past in the shape of old maps, old wooden pipes, old taps, old corroded work, as if to temper the judgment of the present public, and remind them of the changes they have had to pass through as experience has accumulated and knowledge has advanced.

Growing London was still relying on unfiltered river supplies, for East London used the Lea, Mid-London the New River, while West and South London used the Thames, when the visibly filthy state of the Chelsea reach, with an intake of a water company and the mouth of the Raneleigh sewer in close proximity, aroused feelings of dissatisfaction. It needed but a leader to make this dissatisfaction assume the character of a movement. That leader was found in Mr. T. Wright, who in a pamphlet called the "Dolphin" (issued March 19th, 1825), put in words what many people had not troubled to see for themselves. The public at once changed front. They had gladly availed themselves of the supplies the companies afforded them, they were not compelled to take the supplies, there still were wells if not the old streams, but the ease of obtaining water by simply turning a tap influenced many, while others saw in the flowing Thames supply a purer water than that from their own wells. They had accepted the companies' supplies as good. They fouled these supplies by their own house refuse. Then they blamed the companies for pumping back to them their own sewage. The companies had no control of the sewers—the Commissioners of Sewers regulated them.

Sooner or later it must probably have come to Thames or a distant supply, as it seems unlikely from the recent study of the water-bearing strata below London that a sufficient supply could have been obtained.

Inconsistent as the public was in fixing its blame on the companies, the agitation led to good results. The Thames water was analysed by order of a Royal

Commission appointed in consequence of the agitation, and the analyses were entrusted to Doctors Bostock and Lambe.*

Dr. Bostock wrote in his part of the report to the Commission, "It appears that the water of the Thames, when free from extraneous substances, is in a state of considerable purity."

From that time till now the questions—What is an efficient filter bed? what is a proper rate of filtration? what can, and what cannot filtration do?—have led to experimental inquiry by many who have made it their business to investigate such matters, or have had the practical control of them.

The companies here show by actual samples how their filter beds are composed at the present time, while the tables show in figures the acreage of the filters. No two companies' are exactly alike. They are all alike in this, they are downward acting filters, with from two to three feet of sand above, and fine and then coarse gravel for this sand to rest on.

No information is given as to the frequency with which the beds are cleaned—that is, the fouled surface sand removed, and clean sand substituted. But as the filter beds, like all the works of the companies, are under the inspection of Col. Sir Francis Bolton, the official water examiner, appointed in accordance with the Metropolis Water Act of 1871, who has so energetically carried out the duties of the post, it may be assumed that the work is effected in accordance with what is believed to be necessary.

There are two points always to remember in judging of whatever shortcomings there may be on the part of the companies in the attainment of theoretical perfection. First, they have had to find out what they should do in the way of filtering, what is practicable and what is not. They have had only their own experiences to go upon. Our London water supply is one of growth, and difficulties have had to be met as they have arisen. Secondly, they have to deal with natural difficulties, floods and droughts, over which they have no control. During floods the water is very turbid, and to avoid overtaxing the filters, large settling reservoirs are formed to allow the sediment to subside before the water enters the filters.

Whether, after all the trouble taken, the water as delivered is in "a fit state for dietetic purposes" is a question on which the opinion of chemists is divided, on which some have used very vigorous language. The companies make no secret of what they are doing. By placing sections of these filters in so prominent a position, they seem rather courting inquiry. The public have three sets of monthly analyses to inform them how far the work of the filters has been efficient—one set published by the Registrar-General, one set made on behalf of the companies, and paid for by them, and a third independent set. Though they differ in the methods of analysis employed, and differ in the technical expressions of the results obtained, they differ but little as to the essential points. Considerable confusion appears to have arisen from the public not understanding that the reports issued by the Registrar-General refer to samples taken on one day in each month only, so that when a sample is pronounced of excellent quality, or as unfit for dietetic use, it by no means follows the water of that particular company was good or bad during the whole of the month. It has been very justly urged that a water should never be "unfit for dietetic use." The phrase is vague. Theoretically it is what should be aimed at. It can be practically defined only by a conventional standard, and if a company at any time through force of natural difficulties fails to reach it, that company is hardly in the position of a wilful adulterator. So long as river water is used, fluctuations in quality must be expected. They depend on the character and localities of rainfall.

Owing to the powers conferred on the Thames Conservators, extended from time to time, the Thames receives now but little direct sewage. The Conservators, two years ago, even announced in their annual report, "The Thames is now practically free from sewage contamination." Except those who hold that no river water should be used for drinking purposes, all are agreed that the Thames, the Lea, and the New River furnish excellent supplies were it nor for the sewage. The amount of sewage has been reduced, and under the care of the Conservators is still being reduced.

It is now generally admitted that the chief danger from sewage in a river is the chance of the outbreak of a zymotic disease somewhere above the intakes. If on this ground the London public decides to abandon its river supplies, what is to be the alternative? In "Notes on Previous Inquiries," a summary was given of the so-called "heroic schemes" for bringing water from long distances. Engineering difficulties are nothing, for our engineers with money can do anything. Against all the schemes, however, objections have been raised, and it may, perhaps, be wiser to bear the ills we have than fly to others that we know not of. Filtration, such as is shown by the companies, is at present our safeguard.

Household filters properly cared for, are, without donbt, an additional safeguard, and at the Water Supply Conference held in July, at the Health Exhibition, Dr. Bartlett stated he had obtained charcoal finer than the diatom markings used as microscopic tests. This, possibly, would arrest the passage of disease germs.

One obvious practical inference the "water pavilion" collection suggests is, that the perfecting of the water supply of London now depends rather on internal house arrangements than on the energies of the water companies. A large proportion of houses have a supply only in the back yard, and this

* "See "Notes on Previous Enquiries," p. 70. The report itself has been long out of print and is difficult to obtain.

is most frequently in cases where several families are in one house. Insufficient supplies in such cases are not under the control of the companies.

FURTHER NOTES ON SOME MALAY TIMBER TREES.

By James Collins.

In the *Journal* for April 25th, of this year (vol. xxxii., p. 570), some notes on this subject will be found. The present notes are on Malacca timbers, chiefly the results of the observations of the late Dr. A. C. Maingay, who, in 1865, was Resident Assistant-Surgeon at Malacca, and who paid great attention to botanical matters. In the previous article the character and extent of the Malacca forests is there treated of. It need only be said that in the selection of timber the natives show great judgment. Thus wood used for supports, or beams of houses, are as a rule strong, durable, and little liable to attacks of white ants; wood destined for bridge or shore piles withstand water well; furniture and carriage woods are noted for their rich colour, figuring, and capability of taking a high polish; shafts for carriages, &c., for their toughness and elasticity. The furniture, as a rule, is mostly of a European pattern and well made, the Chinese, with their few and simple tools, being adepts at imitating any pattern put before them. Some of the woods used for native sword (kris) handles have a most beautiful figuring, and are capable of receiving a brilliant polish, and intricate and tasteful carving. Many of these woods would, doubtless, prove of the highest value in this country. The following is a list of woods :—

Aetan pandak.—Dirty white colour, with faint brownish minute streaks; fine grain, soft wood. Weight $33\frac{3}{4}$ lbs. per cubic feet.

Aloos surat.—Faint dull red colour; fine grain, hard wood. Used for supports of bridges. Weight $54\frac{5}{8}$ lbs.

Angsanah (*Pterocarpus Indicus*). — Yellowish colour, with elegant brown streaks; medium grain and hardness; used largely for highest class of furniture, &c. Weight $56\frac{3}{8}$ lbs.

Au reyjan.—Yellowish white; coarse grain and soft. Weight $49\frac{5}{8}$ lbs.

Angungum bey.—Faint red, medium grain, hard wood; used for ships' trenails. Weight $54\frac{1}{4}$ lbs.

Babatay bukit.—Faint red, medium grain, and rather hard. Weight 55 lbs.

Babatay paya.—Very pale red, with lighter rings; fine grain, and medium hard wood; used in ship-building. Weight $60\frac{1}{2}$ lbs.

Baleh adap.—White, coarse, and very soft. Weight $29\frac{1}{2}$ lbs.

Baleh angen.—Reddish white, coarse, and soft wood. Weight $35\frac{1}{2}$ lbs.

Bilimbing kraa.—Pale brownish white, with brownish striæ, medium grain and hardness. Weight $49\frac{5}{8}$ lbs.

Bra bras.—Yellowish white, coarse, medium hardness; used for posts of houses, but not very durable. Weight $43\frac{1}{4}$ lbs.

Brombong.—Of a bright yellow colour, and hard. A very valuable and durable tree, not touched by white ants, and valuable for railway sleepers; very common. Weight $56\frac{1}{8}$ lbs.

Chankal feyrak.—Whitish red; coarse and hard. Used for boat beams. Weight 55 lbs.

Chumpaka mera outan.—Orange yellow; medium grain and hardness. Used in making fancy boxes. Weight $50\frac{1}{2}$ lbs.

Champaka puteh outan.—Dull white, with pale brown striæ and circular marking; used for kris (native sword) handles. Weight $48\frac{1}{2}$ lbs.

Chindarey (*jantan*). — Dull olive, coarse and medium hardness; used for yard measures. Weight $55\frac{3}{4}$ lbs.

Chintamola (*jantan*).—Dull red, medium grain and hard; used for making ships' pumps. Weight $53\frac{7}{8}$ lbs.

Dun durian.—Pale red, coarse and soft; used in boat building, but only lasts seven or eight years. Weight $34\frac{1}{2}$ lbs.

Galam (*Melaleuca Leucadendron*).—Dull, reddish or brownish, coarse fibre, medium hardness; very plentiful in marshy places; trunks used for bridge piles, and the bark for caulking boats; the leaves yield cajuput oil. Weight $46\frac{7}{8}$ lbs.

Gyam.—Brownish internally, red towards centre; medium grain and hard wood; very valuable timber, not attacked by white ants. Weight $68\frac{1}{4}$ lbs.

Kacha feyrayng outan.—White, fine and medium hard; grows to an immense size; buttresses used as cart wheels. Weight $51\frac{1}{2}$ lbs.

Kandeys.—Pale dull red, fine and very hard; used for supports of houses. Weight $63\frac{3}{4}$ lbs.

Kasambee.—Dull red, medium grain and hard; used for ships' blocks. Weight $51\frac{1}{8}$ lbs.

Kasambee jantan.—Dull, dark red, medium grain and hard; used for boxes of wheels. Weight $66\frac{1}{4}$ lbs.

Katak tangga.—Dull, dark red, medium grain and hardness; used for domestic bowls, &c. Weight $58\frac{1}{2}$ lbs.

Kayu arang (*Diospyros sps*).—One of the ebonies of commerce, heart wood black; outer wood pale brown; fine grain and exceedingly hard. Weight 81 lbs.

Kayu gading.—Very pale whitish red, medium grain, very hard; used for kris handles, and has been recommended for engraving and carving purposes. Weight $65\frac{1}{2}$ lbs.

Kayu klut boey.—Pale brownish white, fine grain and rather hard; used as pestles for crushing paddy. Weight $49\frac{1}{2}$ lbs.

Kayu klut jambu ayer.—Dull red, medium grain and hard; used for supports of houses. Weight $50\frac{1}{4}$ lbs.

Kayu klut merah.—Dull red, fine, very hard; a valuable timber. Weight $64\frac{7}{8}$ lbs.

Kayu klut nassee.—Dull red, fine and hard; used as beams in large houses; a very valuable timber. Weight $61\frac{1}{4}$ lbs.

Kayu klut sama.—Red, fine and hard; used as pestles for pounding paddy. Weight $62\frac{1}{4}$ lbs.

Kayu malookool.—Dull white, medium and soft; used for kris scabbards. Weight $43\frac{1}{4}$ lbs.

Kledang.—Reddish olive brown, very coarse and soft, but very durable underground, and is the favourite wood for Chinese coffins. Weight $39\frac{3}{4}$ lbs.

Kookoo.—Pale dirty red, with lighter streaks, coarse and rather hard; a good furniture wood. Weight $50\frac{1}{4}$ lbs.

Krantie.—Dirty white, medium grain, and rather hard; used for gun stocks. Weight $42\frac{1}{4}$ lbs.

Lebun bunga.—Yellowish white, medium grain, and hard; used for boat building. Weight $51\frac{1}{4}$ lbs.

Matakaley.—Pale brownish white, coarse and rather hard; used for blades of oars. Weight $41\frac{3}{4}$ lbs.

Mata kuching.—Yellowish or brownish white, medium grain and rather hard; much prized for furniture. Weight $63\frac{5}{8}$ lbs.

Mata passeh.—Very pale lemon, fine grain, and rather hard; used for table making. Weight $45\frac{7}{8}$ lbs.

Medang ketaneh.—Dull olive, coarse and soft; largely used by Chinese for elaborate carving, and also valuable in house building from its pliancy. Weight $40\frac{1}{4}$ lbs.

Meyko.—A clear gamboge yellow, medium grain and hardness; used for the sliding lids of Chinese coffins. Weight $49\frac{3}{4}$ lbs.

Mim pesasang.—Pale brownish, fine and rather hard; used for gun stocks. Weight $51\frac{1}{2}$ lbs.

Mirlang.—Pale yellowish buff, fine and hard; used for kris handles. Weight $58\frac{5}{8}$ lbs.

Mursawa.—Reddish white, medium grain, and soft; a large tree used in making "dug-out" canoes. Weight $54\frac{1}{2}$ lbs.

Nepees kolele.—Reddish white, fine and hard; used for carriage shafts. Weight $63\frac{3}{8}$ lbs.

Petalling.—Dull reddish brown, fine and hard; used for the main supports of houses. Weight $63\frac{3}{8}$ lbs.

Plangee.—Light brown, medium in grain and hardness, and very durable; used for gun stocks. Weight $48\frac{1}{2}$ lbs.

Rassak.—Very pale lemon, fine and hard; makes valuable beams. Weight $51\frac{1}{8}$ lbs.

Roominyah.—Yellowish white, with brownish centre, medium grain and hardness; used for kris scabbards. Weight $58\frac{1}{4}$ lbs.

Ruriang.—Pale whitish red, with dark centre; very fine and very hard, and heavier than the ebony of Malacca. Weight 82 lbs.

Sama jawa.—Very pale red, fine and hard; used in boat building and for beams. Weight $59\frac{1}{4}$ lbs.

Samak ayam.—Pale brown, medium texture and hard; used for beams. Weight $61\frac{3}{8}$ lbs.

Sipfatay.—Very pale lemon, coarse and hard; used for beams, &c. Weight $50\frac{1}{2}$ lbs.

Sugee (jantan).—Dull red in parts, coarse and hard; used for carriage sides. Weight $60\frac{1}{4}$ lbs.

Tajoo.—Pale reddish, darker in centre, medium grain and hard; used for the main beams of roofs; a valuable timber. Weight $48\frac{1}{2}$ lbs.

Tamponee (Artocarpus echinatus).—Orange red, coarse grain and soft; used for beams, furniture, chairs, &c. Weight $39\frac{3}{4}$ lbs.

Taytyoof.—Pale red, fine and hard; used for house beams. Weight $57\frac{5}{8}$ lb.

Tetey yoo.—Dull red, fine and hard; used in house building. Weight 56 lbs.

Traling.—Very pale red, darker in centre, medium grain and hardness; largely used for cart wheels. Weight $52\frac{3}{8}$ lbs.

UNION OF SANITARY AUTHORITIES FOR ADMINISTRATIVE PURPOSES.

The following remarks on the disadvantages of the union of sanitary authorities for administrative purposes are taken from Mr. C. N. Cresswell's speech last week, in an inquiry before John Thornhill Harrison, Esq., at Kingston-on-Thames:—

"He was opposed to all combinations of sanitary authorities, such as this Joint Board, upon general grounds, as well as upon special grounds applicable peculiarly to Heston and Isleworth, on account of its geographical position and its physical peculiarities. His objection to any Joint Board was that it was altogether inconsistent with the principles upon which the liberties of this country were founded, and by which they had been developed—local self-government itself. He objected to it, because this fusion—or he thought he might say confusion—of interests was at variance with the great principle of local independence. Because it tended to deprive the constituent authority, which was merged in the larger authority, of all practical financial control over their own expenditure. In the case of Heston and Isleworth, of what use was it for the Local Board to meet together for the purpose of performing their duties, and economising their expenditure, by saving in little parsimonies a penny in the pound here, and a halfpenny in the pound there, when a Board over which they had practically no control, but in which they were supposed to be represented, came with one fell swoop, and took away every single penny that several years of hard economy had saved. Surely it was a mockery of self-government to say that the pennies should be husbanded by the local authority, while the pounds were spent by the Joint Board. It was the opinion of everyone who had studied the question philosophically, that the great evil of combinations was that they augmented all the difficulties with which they had to contend. In the case of sewage disposal, it was easier to deal with the unit than with the aggregate. The experience of the past ten years must have shown the inspector how much easier it was for separate and independent local bodies to obtain the necessary land as the site for the disposal of their sewage, than it was for a combination

of authorities to obtain a much larger quantity of land. They were all aware, by painful experience, of the extreme difficulty of obtaining even fifty acres of land in this district for the purposes of the Joint Board. But apart from the difficulty of acquiring land, there was the great difficulty, so familiar to the inspector, arising from the volume of sewage to be treated of itself. Long arguments took place as to the necessity of prescribing how much every house should be permitted to contribute to the general body of sewage, because it was foreseen that the magnitude of the work to be done would create in itself an enormous difficulty almost impossible to be overcome. It was also imposed upon all the constituent authorities, as a matter of equity, that they must separate the sewage from the rainfall throughout the whole district. That was then, and is now, the *crux* of the whole question, for separating the rainfall from the sewage would inflict upon some of the constituent authorities the most disastrous consequences. Were it not for that unfortunate 'prescribed quantity' clause, which had been so much a bone of contention, and the subject of discussion for the last seven years within this district, there would, perhaps, have been no difficulty in the matter; but that clause imposed upon some of the urban authorities of the combination a most serious and almost invincible local difficulty, which justified them in their endeavour to obtain separation from the Joint Board, or the alternative of the dissolution of the Board altogether. That was one of the inherent vices and intrinsic difficulties which struck at the very root of combinations for sanitary purposes. At the same time, an equitable adjustment of the burden to be borne by each of the constituent authorities was absolutely necessary, if they were to act together and in common accord, and to limit as far as possible the difficulties of the work to be achieved. The relative difficulties in that respect were illustrated by towns like Richmond and Kingston on the one side, and the rustic arcadias of Esher and Hook on the other side. Heston and Isleworth, like Esher and Hook, fortunately, were not sewered, and, therefore, when called upon to limit the sewage to the prescribed quantity, they would have nothing whatever to do but to follow the advice of their surveyor, and lay down their drains accordingly, without incurring any unnecessary expense whatever in the operation. But other places, like Kingston and Richmond, were situated very differently, and must dispense with all they had done, throw to the winds all the expenses which they had incurred for the last 30 years, re-sewer under circumstances of the greatest difficulty their main streets, and re-connect every one of their houses at a very considerable expense—calculated at from £8 to £10 per house—solely to conform to a restriction imprudently imposed by the Act of Parliament. That in itself was an argument against combination. Then again, this combination contained rural districts with populations of about one to the acre, which were combined with suburban districts containing populations of perhaps 100 to the acre. That was to say, they had districts where the assessable value was chiefly in land, combined for one and the same purpose with districts where the whole of the assessment was upon houses, and there was therefore an inequality of burdens to be borne by those several authorities, which in itself imposed upon those who had land as a large proportion of their assessable value a grave injury and injustice. If Surbiton, with all its land built over, was called upon to pay a rate of 1s. in the £, the neighbouring rural districts would have to contribute a rate of 1s. 11¼d. to meet a call levied on the basis. How could it be possible to argue that an alliance, such as he described, could ever be based upon equitable grounds, or could endure? Again, painful experience had shown them that the system of representation on the Joint Board was in itself most vicious and opposed to equity. It was assumed that each one of the authorities had its representatives on the Joint Board, whose special duty and vocation it should be to represent the recorded resolutions and determinations of the several local authorities. Never was there a greater illusion. Experience had shown that it was with the Joint Board as it was with every other Board, that one or two commanding minds and energetic spirits controlled the members, and the farce of representation had become a bye-word throughout the whole district."

Correspondence.

SANITATION IN JAPAN.

Permit me to confirm the opinion expressed by Mr. Brunton in last week's *Journal* on this subject, when referring to Mr. Ernest Hart's recent paper.

That the Japanese are a wonderful and curiously clever people, and possessed of an ancient civilisation, will be generally admitted, but the statement that such civilisation, in its extension throughout Japan, is in immediate contact with the last results of European scientific knowledge, is certainly one open to serious question.

Mr. Brunton, from his late official position and long residence in Japan, may be regarded as an authority on this question, and the remarks in his letter, and in the paper to which he alludes, go to support the views I formed, while in Japan, on Japanese dwellings, and which are expressed in a paper of mine, presented to the Asiatic Society in 1878, and published in their "Transactions." Regarding the sanitary arrangements of Japanese houses, and the great importance of a good water supply and efficient sewerage, I then remarked, "It may be said, without much fear of contradiction, that the open drains bordering most of the streets in Japanese owns, and taking their loathsome trail under the

threshold of most of the dwellings, do not fulfil good sewerage conditions, and it may also be as positively affirmed that the open wells in the streets, supplied mostly by surface-water percolating through soil loaded with putrid and excrementitious matter, do not satisfy our notions of wholesome drinking water." And in regard of the quality and durability of Japanese structures, I also remarked, "I entertain the opinion that few really good brick or stone buildings exist in the country. There are many structures, it is true, pretending to this character, but the most of them are lacking in essential qualities. I might instance the composite buildings of wood and stone, commonly erected in Yokohama and Tokio; and we may see that, after a few years' existence, they are rapidly on the way to decay, and require constant repair. Their non-liability to take fire is more fancied than real; and yet this mongrel style of buildings, or one in which tiles and plaster replace stone, is now being largely used by the Government for the numerous departmental offices in Tokio and other places."

There is reason to believe that the foregoing remarks apply with equal correctness now as when written in 1878, and certainly do not present such a favourable view of sanitation in Japan as Mr. Hart's paper describes.

In conclusion, let me add, that I fully agree with Mr. Brunton in regard of the arrogance of opinion and shallow conceit of a large body of Japanese, and of the minor Government officials especially. Some gentlemen who have been in the service of the Japannese Government, and with the heartiest goodwill and energy have striven to make their services a lasting good to the country, will no doubt keenly recollect how often their best efforts and intentions have been upset by this conceit, and the profonnd mistrust which probably is the result of the hateful espionage of feudal times, and which is still, to some extent, a feature in the national character, giving rise to systematic dissimulation.

Notwithstanding the above remarks, I claim to take as friendly an interest in the solid and permanent progress of Japan as the writers who, from a superficial acquaintance, or other reasons best known to themselves, give it unqualified praise, and to which these comments may be considered a form of corrective.

GEORGE CAWLEY, M.Inst.M.E.
Late of the Imperial College of Engineering, Tokio, Japan.
Birch-villas, Northen-grove,
Didsbury, near Manchester.
December 8th, 1884.

SMOKE PREVENTION.

My letter has raised a storm of correspondence, to which it is impossible to reply singly. The steam boiler is an externally fired plain cylinder, with round ends, carried by webs at each side, so as to allow a flue to envelope one-half the circumference. The flue does not return. Boiler, 3 ft. 6 in. diameter; fire, 3 ft. 6 in. wide; fire-bars, 2 ft. 6 in. long. At the end of the fire-bars, the bridge rises as a semi-circle to within 5 inches of the boiler, and this is continued the whole length, making a very wide and shallow flue. The boiler is 15 ft. long, and the feed water-tank is set in the centre of the flue, close to the end of boiler. The waste heat is so small, that the feed-water becomes barely warm to the hand; it is, for all practical purposes, cold. The fire-bars are set twelve inches below the bottom of the boiler; the fuel is gas coke, the water and steam space are very large, and the boiler gets scant attention and irregular firing, the average evaporation for three years past is $7\frac{1}{4}$ lbs. water per lb. gas coke, the boiler being usually driven to its maximum capacity, and therefore not very economically. Coke, broken small, is used in the smithy fires, and the same fuel is also used in the tinmen's stoves, all the fuel being, of course, smokeless. The baking of japanned work is done by gas, as is also all ordinary brazing. An exception, so far as the fire under the boiler is concerned, may be made in the fact that we bank up with a small quantity of close slack, but this makes very little smoke when the first spark breaks through the surface. We do not always bank up, as the boiler holds its heat extremely well. In the house we have a plant-house, with about 140 ft. of 4 in. pipe, and a large reserve tank for equalising the heat, and doing away with the necessity for any night firing. This arrangement is heated by a boiler, consisting of four coils of 1 in. steam-pipe —coils of 8 in. diameter, two inches apart, fired from the top; this has worked perfectly with coke for five years; average cost of coke, 28s. 6d. per annum; minimum of 50° kept in one of the plant-houses. The washing, drying, airing of clothes, and ironing are done practically entirely by gas, fire being never used unless it happens to be required for something else. If a fire exists in the kitchen grate, the range over is used, assisted, when necessary, by a gas-burner in the oven; if not, the gas-oven and boilers are used for all cooking. Water for scullery purposes is heated over the scullery sink in a small cylinder, with a low power gas burner underneath, the cylinder being self-filling. Bath water is heated in the bath-room in a small tank with burners under, as we have only a small gas-pipe, and no flue available. Gas is used exclusively for fires, except in the kitchen, and it will be used there also in a short time, the fires being all made of a block of very porous fire-clay, with asbestos fibres. The price of gas here is 3s. 3d. per 1,000 ft. The total gas bill, including lighting (which we estimate at £8 per annum), was £20 14s. for 1883, and £21 10s. for 1884, gas accounts being made up to November each year. Four tons of coal have been paid for in two years, but not all used; ordinary supervision has been exercised in the use of gas, but no special care. We average ten or eleven in the household; house contains three sitting-rooms and

eight bedrooms, with usual accessories. We use gas freely, but as will be seen, we do not pin our faith on its exclusive use; it is simply a question of which fuel suits us, and pays best to use.

THOMAS FLETCHER.

ELECTRIC LIGHTING IN AMERICA.

Many points of vital importance await the light of critical discussion before anything like uniformity can be arrived at in the carrying out of practical installations. This is manifest from the fact that in the discussion on Mr. Preece's valuable paper, in which only four speakers—including the chairman—took part, such great differences of opinion existed not only on the American systems of electric lighting, generally, but also on such definite points as the reliability of Edison's electro meter, and the comparative merit of high and low tension currents. There can be no doubt, as Mr. Preece said, the measurement of electricity by the electro-deposition of metals, as used in the Edison meter, is scientifically correct, and in every way well suited to the laboratory; but as a meter for practical use, it is very defective in that, not being a self-recording instrument, it cannot be read by the unskilled consumer. I have given considerable attention to this part of the subject, and in conjunction with Mr. J. R. Shearer, have brought out a meter which removes the whole of the difficulty. In its simplest form it consists of a hydrometric float carrying an electrode, and graduated to indicate the amount of current passed by the electro-deposition and dissolution of metals. The other electrode is attached to the containing jar. It is, therefore, both scientifically accurate and perfectly practicable.

The high and low potential question has now reached a point analogous to what in railway matters was termed the "Battle of the Gauges," the high potential corresponding to the narrow, and the low potential to the broad gauge, and I have no doubt it will terminate in a similar way. For local or limited installations, such as the lighting of the Royal Courts of Justice, the low potential system has the charm of simplicity, but for lighting from central stations the economy is entirely in favour of the high potential system. Under the latter, the output at the dynamo can be doubled with but slight increase in its cost, but the great economy under it is the enormous saving in the cost of leads, as the same sectional area of conductor with twice the potential will do double duty. It is to be hoped the Government will be wise enough to repeal the sections of the Electric Lighting Act which render the use of low tension currents compulsory, for if these sections are repealed, the same equivalent of light could be obtained at from one-fifth to one-half the cost, and there would be no necessity for converting our streets into veritable copper mines.

I do not agree with Mr. Preece and Mr. Hammond that electric light need now be more expensive tha gas, nor in any sense a luxury. For domestic lightin it is not necessary to adhere to the incandescen sytem small arcs of from 80 to 100 candle-powe requiring a current of about 120 watts are muc more economical, and when the electrodes are mad of flexible carbon these lamps require very littl attention. We entered a lamp of this descriptio for the International Health Exhibition, but, un fortunately, could not get it completed in time fo exhibition. It is now complete, and will soon b before the public.

FREDERICK H. VARLEY.

The Varley Electric Patents Proprietory's Works, Ball's-pond, N.

Notes on Books.

THE LAW RELATING TO GAS AND WATER, com prising the rights and duties as well of loca authorities as of private companies in regar thereto. By W. H. Michael, Q.C., and J. Shires Will, Q.C.; third edition by M. J. Michael London: Butterworths, 1884.

The last edition of this work was issued in 1877 since which year certain changes have been made i the law by the Public Health (Water) Act, 1878, th Public Health (Support of Sewers Amendment Act, 1883, and the Land Clauses (Umpire) Act, 1883 A change in the procedure for the recovery o penalties by gas and water companies in Englan has also been made by the Summary Jurisdictio Act, 1884. The effect of these Acts is explained i the present edition, and all recent decisions ar inserted in the text, while those which have bee overruled are removed. The work is divided int two parts, the first referring to gas and the secon to water. At the beginning of the book is a alphabetical table of cases, and at the end a ful index.

INDIAN AND COLONIAL MANUAL AND DIAR FOR 1885. London: A. H. Wheeler and Co 1884. 8vo.

This, which is a second issue of the Manual, contains an account of all the British possessions i Asia, Australia, America, West Indies, Africa an the Atlantic and Indian Oceans, as well as th Home dependencies. It also contains a blank diar for every day in the year.

CHRISTMAS AND NEW YEAR'S PRESENTATION CARDS. 1884-85. Harding, 157, Piccadilly.

Mr. Harding has issued for the Christmas season a variety of cards in colours and monochrome. Among the subjects are incidents of hunting by A. Roberson;

porting dogs, by R. H. Moore; and primæval conceptions, by Ernest Griset.

CHRISTMAS AND NEW YEAR'S CARDS. Davidson Brothers, 9, Jewin-street, E.C.

Messrs. Davidson have produced a collection of appropriate cards for the present Christmas, which consist of floral designs, views and figures, pieces printed in colours and in a variety of forms, with appropriate mottoes on the back.

Obituary.

AUGUSTUS VOELCKER, Ph.D., F.R.S., died on Dec. 5th, at his residence, 39, Argyll-road, Kensington. Born at Frankfort on the Maine, in 1823, he received his chief education at the University of Göttingen, and in early life came to England. He was assistant to the late Professor Johnston at Edinburgh in 1849, and was appointed Professor of Chemistry in the Royal Agricultural College at Cirencester in 1852; he held this office until 1862, when he became Professor of Chemistry to the Royal Agricultural Society of England. He was the author of several works, as the "Chemistry of Food" "Chemistry of Manures," "Lectures on Agricultural Chemistry," and contributed numerous papers on theoretical and agricultural chemistry to scientific journals. He was elected a member of the Society of Arts in 1863. In 1864 he read a paper on the injurious effects of smoke; and in 1871, one on the sugar beet in England. He was a frequent speaker at the meetings whenever agricultural subjects were discussed.

General Notes.

RAILWAY PROGRESS IN NEW SOUTH WALES.—In 1883, the total earnings of the New South Wales railways were £1,931,464; total working expenses, £1,177,188; and the net earnings £753,676. The total cost of construction amounted to £14,382,102; the cost of rolling-stock, workshops, machinery, furniture, &c., was £2,520,912; and the total capital expended £16,905,014. But for heavy reductions of charges, the receipts would have been increased by £100,000.

INDUSTRIAL PROPERTY PROTECTION. — The *Feuille Fédérale Suisse* announces the intended publication, from January the 1st next, by the International Office of the Union for the Protection of Industrial Property, of a monthly official journal in the French language, to be entitled, *La Propriété Industrielle*, which is to serve as a medium for the publication of all official intelligence emanating from the union, and for the exchange of information connected with those subjects, in the interests of which the union has been established. The subscription to this journal, which is to be published by MM. Jent and Reinert, at Berne, will be five francs annually, exclusive of postage.

ROYAL INSTITUTION.—The following are the lecture arrangements at the Royal Institution before Easter, 1885:—Six lectures (adapted to a juvenile auditory) by Professor Tyndall, on "The Sources of Electricity," on Dec. 27, 30, 1884, Jan. 1, 3, 6, 8, 1885; five lectures by Professor H. N. Moseley, on "Colonial Animals: their Structure and Life Histories," on Tuesdays, Jan. 13 to Feb. 10; four lectures by Dr. Arthur Gamgee, on "Digestion," on Tuesdays, March 3 to 24; eleven lectures by Professor Dewar, on "The New Chemistry," on Thursdays, Jan. 15 to March 26; three lectures by Dr. Waldstein, on "Greek Sculpture, from Pheidias to the Roman Era," on Saturdays, Jan. 17 to 31; three lectures by Mr. C. Johnstone Stoney, on "The Scale on which Nature Works, and the Character of of some of her Operations," on Saturdays, Feb. 7 to 21; and five lectures by Mr. Carl Armbruster, on "The Life, Theory, and Works of Richard Wagner" (with illustrations, vocal and instrumental), on Saturdays, Feb. 28 to March 28. The Friday evening meetings will begin on January 16, when Professor Tyndall will give a discourse on "Living Contagia."

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

DECEMBER 17.—"Present and Prospective Sources of the Timber Supplies of Great Britain." By P. L. SIMMONDS. Sir CHARLES TUPPER, K.C.M.G., C.B., High Commissioner for Canada, will preside.

At the meetings after Christmas, the following Papers (among others) will be read.

"The Employment of Hydraulic Machinery in Engineering Workshops." By RALPH H. TWEDDELL.

"The History and Manufacture of Playing Cards." By GEORGE CLULOW.

"The Musical Scales of Various Nations." By A. J. ELLIS, B.A., F.R.S.

"A Marine Laboratory as a means of Improving Sea Fisheries." By Prof. E. RAY LANKESTER, M.A., F.R.S.

"Labour and Wages in the United States." By D. PIDGEON.

"Recent Improvements in Coast Signals." By Sir J. N. DOUGLASS.

"The Influence of Civilisation upon Eyesight." By R. BRUDENELL CARTER, F.R.C.S.

"The Evolution of Machines." By Prof. H. S. HELE SHAW.

"Tempered Glass." By FREDERICK SIEMENS.

"The American Oil and Gas Fields." By Professor JAMES DEWAR, F.R.S.

"Past and Present Methods of Supplying Steam Boilers with Water." By W. D. SCOTT MONCRIEFF, M.Inst. C.E.

HOWARD LECTURES.

Thursday evenings at Eight o'clock.

A special Course will be delivered under the Howard Trust, on "The Conversion of Heat into Useful Work." By W. ANDERSON, M.Inst.C.E.

LECTURE IV. JANUARY 22.—The working substances in Heat-engines. Gunpowder Gases. Coal Gas. Hot Air. Steam. The method and cost of preparing the working substances. The theoretical Calorific Power of Fuels, the Degree of Efficiency to be expected, and the Efficiency actually realised.

LECTURE V. JANUARY 29.—The Discharge of Artillery; Work done on the Projectile, and on the Gun and Carriage; Limits of Efficiency. Gas-engines; Nature of their Action, Mechanical details, Limits of Efficiency, Results actually obtained.

LECTURE VI. FEBRUARY 5.—Hot Air-engines; Nature of their Action, Mechanical details, Limits of Efficiency. Compressed Air Refrigerating Machines. The Steam-engine, Non-condensing, Condensing, and Compound; Nature of its Action, Mechanical details, Limits of Efficiency, Results actually obtained.

CANTOR LECTURES.

Monday Evenings at Eight o'clock. The First Course will be on "The Use of Coal Gas." By HAROLD B. DIXON, M.A.

LECTURE III. DEC. 15.—Coal Gas as a source of Heat.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DEC. 15...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Harold B. Dixon, "The Use of Coal Gas." (Lecture III.)

British Architects, 9, Conduit-street, W., 8 p.m. Mr. Lawrence Harvey, "Semper's Theory of Evolution on Architectural Ornament."

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m. Mr. R. N. Cust, "The Languages of the Caucasus."

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. G. J. Romanes, "Is the Human Mind of Animal Origin?" (Part I.)

TUESDAY, DEC. 16... SOCIETY OF ARTS, John-street, Adelphi, W.C., 4 p.m. (Special Lecture.) Dr. B. W. Richardson, "The Painless Extinction of Life in the Lower Animal."

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Adjourned discussion on papers by (1) Hon. R C Parsons, "The Working of Tramways by Steam." (2.) Mr. W. Shellshear, "The Sydney Steam Tramways."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m. Mr. J. S. Jeans, "English and Foreign Labour Compared."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

WEDNESDAY, DEC. 17...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. P. L. Simmonds, "The Present and Prospective Sources of the Timber Supplies of Great Britain."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Dr. Julius Hann, "The Reduction of Temperature Means from Short Periods of Observations to the Equivalents of Longer Periods." 2. Mr. Charles Harding, "The Diversity of Scales for Registering the Force of Wind." 3. Rev. T. A. Preston, "Report on the Phenological Observations for 1884."

Geological, Burlington-house, W., 8 p.m. 1. Mr. C. Lloyd Morgan, "The South-western Extension of the Clifton Fault." 2. Mr. G. R. Vine, "Notes on Species of *Phyllopora* and *Thamniscus* from the Lower Silurian Rocks, near Welshpool, Wales." 3. Prof. E. W. Claypole, "The Recent Discovery of Pteraspidian Fish in the Upper Silurian Rocks of North America."

Sanitary Assurance Association, 74A, Margaret-street, W., 7½ p.m. Dr. W. B. Beatson, "Sanitation at a Health Resort."

Royal Society of Literature, 4, St. Martin's-place, W.C. 8 p.m. Mr. R. N. Cust, "A Trip to the Midnight Sun."

East India Association, Lower Hall, Exeter Hall, W.C., 2½ p.m. Mr. N. S. Ginwalla, "The Indian Civil Service."

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Dr. G. Selkirk-Jones "The Utilisation of State Débris" (with experiments).

Hospitals Association, 1, Adam-street, Adelphi, W.C., 8 p.m. 1. Prof. Marshall, "Hospital Circular Wards." 2. Mr. Keith D. Young, "Short Description of the Miller Memorial Hospital at Greenwich."

THURSDAY, DEC. 18...Royal, Burlington-house, W., 4½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. H. O. Forbes, "Contrivances for Self-Fertilisation in some Orchids." 2. Prof. Mivart, "Brain of Carnivora." 3. Mr. C. B. Clarke, "The Plants of Darjeeling." 4. Mr. T. E. Gunn, "Ornithological Notes." 5. Mr. F. C. S. Roper, "Aerial and Submerged Leaves of *Ranunculus lingua*."

Chemical, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 7 p.m. (Travers Lecture.) Mr. H. Shearman, "The Laws of Carriage." Part I. Goods.

Historical, 11, Chandos-street, W., 8 p.m.

Numismatic 4, St. Martin's-place, W., 7 p.m.

FRIDAY, Dec. 19...Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. F. H. Hebblethwaite, "The Difference in Design of British and Foreign Locomotive Engines."

Philological, University College, W.C., 8 p.m. Mr. James Leeky, "The Fonetics of English Prosody."

CORRECTION.—Page 78, col. 1, line 29, *for* sixteen burners stoves *read* sixteen Tinmen's stoves.

Journal of the Society of Arts.

No. 1,674. Vol. XXXIII.

FRIDAY, DECEMBER 19, 1884.

All communications for the Society should be addressed to Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

All the tickets for these lectures having now been disposed of, the issue is stopped. As all the available accommodation will be required for those members who have applied for tickets, it will be understood that no member can be admitted without a ticket.

The lectures will commence at seven o'clock.

HOWARD LECTURES.

Mr. W. Anderson, M.Inst.C.E., delivered the third of his course of lectures on "The Conversion of Heat into Useful Work," on Thursday evening, December 11th.

CANTOR LECTURES.

The third and concluding lecture of the first course of Cantor Lectures, on the "Use of Coal Gas," was delivered by Mr. Harold B. Dixon, M.A., on Monday evening, December 15th. The special subject of the lecture was Coal Gas as a Source of Heat. A cordial vote of thanks to the lecturer for his interesting course of lectures was carried on the motion of the Chairman.

The first lecture will be printed in the next number of the *Journal*.

DR. RICHARDSON'S LECTURE.

On Tuesday afternoon, December 16th, a lecture on "The Painless Extinction of Life in the Lower Animals," was delivered by Benjamin W. Richardson, M.A., M.D., F.R.S. The lecture will be printed in the next number of the *Journal*.

THE TEN-VOLUME INDEX TO "JOURNAL."

The index to the *Journal of the Society of Arts*, volumes xxi. to xxx. (1872-82), is now ready, and can be obtained gratis by members on application to the Secretary, John-street, Adelphi.

Some copies of the two previous ten-volume indexes are still in stock, and can also be obtained by members on application.

The price to non-members of each index is half-a-crown.

Proceedings of the Society.

FIFTH ORDINARY MEETING.

Wednesday, December 17, 1884; Sir Charles Tupper, K.C.M.G., C.B., High Commissioner for Canada, in the chair.

The following candidates were proposed for election as members of the Society:—

Barnett, William Hyde, 11, New Gravel-lane, Shadwell, E.
Dobbs, Samuel, 1, Sherriff-road, West Hampstead, N.W.
Ebner, Joseph Frederick, 15, Doughty-street, Mecklenburgh-square, W.C.
Janes, George F., The Laurels, New Southgate, N.
Leage, Richard William, Shenfield, 17, Carleton-road, Tufnell-park, N.
Mackinlay, Frederick, 36, Alsine, Buenos Ayres.
Mansfield, William H. Stanley, Richmond College, Surrey.
May, Oliver, The Gas Works, Plymouth.
Shepherd, James, 45, Via Stella, Milan.
Smith, John Nidd, 85, South-street, Greenwich, S.E.
Whitworth, Charles Henry Billingshurst, Godswell, Bloxham, near Banbury.

The following candidates were balloted for and duly elected members of the Society:—

Bidwell, Shelford, Riverstone-lodge, Wandsworth, S.W.
Binswanger, Gustave, 29, Aldermanbury, E.C.
Coscia, C. F., 20, Wellington-square, Oxford.

Glover, James William, Ranelagh Works, Royal-avenue, Chelsea, S.W.
Laurence, Reginald, Cavendish-road, Clapham-park, S.W.
McLauchlan, David J., 29, Union-grove, Clapham, S.W.
McMinn, Arthur Charles, Western-house, Kensal-green, W.
Müller, Hugo, Ph.D., F.R.S., 110, Bunhill-row, E.C.
Oliver, John H., 123, Stamford-street, S.E.
Rickard, John Perrott, junior, 5, Motcombe-street, Belgrave-square, S.W.
Roberts, Thomas, Portmadoc.
Turner, H. H., 9, Humber-road, Westcombe-park, Blackheath, S.E.
Wyles, Frederic, Telegraph Department, Waterloo Station, L. & S.W.R., S.E.

The paper read was—

PAST, PRESENT AND FUTURE SOURCES OF THE TIMBER SUPPLIES OF GREAT BRITAIN.

By P. L. Simmonds.

From its insular position, limited area, and dense population, Great Britain is more dependent on foreign countries for supplies than most nations. Especially is this the case in articles of food and the raw materials for most of our principal manufactures. We are, it is true, rich in the mineral resources of coal and iron, but for one important substance—wood, we are largely dependent on foreign supplies, and the demand is ever on the increase. The immense progress of building operations in the metropolis and other large towns, and in our shipbuilding yards, to say nothing of the multifarious minor employments of wood for railways and telegraph poles, for furniture, for matches, and even for paper-making prove this. Much as iron is now used, it cannot in many instances, replace wood.

As the subject of our timber supplies is, then, one of very extensive and growing importance, I have thought it might be usefully brought before the members. After some considerable amount of research, I have brought together a mass of data relating to the production, export, and consumption of wood in different countries, extending over a period of about a quarter of a century. Not that I intend to weary my audience with the tabular series of figures which I have condensed; I shall merely content myself this evening with summarising them where necessary. But as they are for the most part derived from official sources, the statistics given may be considered reliable, and will prove useful, when published, for reference by those specially interested in our timber supplies. I may here add that no more competent chairman could have been found to preside over such a meeting as this than the official representative of our largest timber-producing colony.

In view of the diminishing supply of timber from nearly every foreign country, extended official inquiries were set on foot by the Colonial and Foreign Offices some six years ago, to ascertain how far we could depend upon our own possessions to supply our undoubted deficiencies at home. The information thus obtained, although useful to a certain degree, was very incomplete. Since that time the subject has lost none of its interest, and the importance of the investigation is evidenced by the increased desire to obtain further statistics and details, ranging over a longer period. The Committee of the Edinburgh Forestry Exhibition recently invited essays on this subject, and the present paper was one of those rewarded.

The immense importance of the extraneous supply of wood to this country is proved by the magnitude of our imports as shown in the Board of Trade returns for the last two years. These exceeded £18,000,000 in value, to say nothing of our home supply of wood. But there are other forest products imported of considerable value, as is shown in the following figures, which brings up the total value of forest products to over £31,500,000.

Value of our Imports of Forest Products.

	1882. £		1883. £
Wood and timber	17,806,632	..	17,742,660
Peruvian bark	1,790,220	..	1,423,516
Cork bark	764,953	..	680,570
Tanning barks	127,186	..	180,749
Valonia	526,361	..	484,228
Dyewoods	432,218	..	522,739
Extracts of ditto and of bark	371,417	..	892,797
Wood pulp for paper ..	502,973	..	445,358
Galls	80,712	..	108,945
Turpentine	640,099	..	555,902
Pitch and tar	150,445	..	176,500
Resin	401,296	..	400,938
Lac products	346,420	..	346,231
Kowrie & other gums and resins, about ..	700,000	..	742,654
Caoutchouc	2,754,692	..	3,652,817
Gutta percha	539,814	..	476,881
Piassava, coir, palmetto, and other tree fibres (assumed about)	200,000	..	240,000

	1882.		1883.
	£		£
Vegetable ivory nuts ..	25,413	..	18,091
Wood naphtha	10,925	..	6,032
Cocoanut and palm oil	1,450,920	..	1,681,275
Sago	219,232	..	219,660
Cinnamon...........	103,281	..	96,252
Brazil nuts, coconuts, and other edible nuts	446,114	..	455,124
	£30,391,332	..	£31,548,919

With the bulk of these items I have not to deal in this paper, but they at least show our large dependence on various forest products from abroad.

The continuous extension of railways in different countries causes an immense demand for timber. The sleepers or "ties," as they are termed in America, vary in dimensions, according to the gauge. They range from 10 ft. × 10 in. by 5 in. on the broad gauge to 6 ft. 6 in. by 4½ in. for the narrow gauge. They may be taken, however, to average 9 ft. long by 8 in. by 4 in. (or say three cubic feet). Assuming the distance apart at which ties are placed at 3 ft., this requires 1,760 ties for each mile of single line. The average duration of ties appears to be from five to seven years, therefore one-seventh, at least, of the original number of ties must be supplied every year.

The railroad companies in America almost invariably require young and growing trees, such as are large enough to make one tie for each cut. Trees of this size will not average more than two cuts each. Consequently the construction of the existing roads in North America alone must have taken 90,178,880 trees.

The following is an approximate return of the total number of miles of railway open in different countries according to the latest data. There are certainly more than 290,000 miles of railways at present in operation, and the average increase is about 10,000 miles a year.

	Miles.	
EUROPE.		
United Kingdom............	18,681	
France	18,000	
Russia and Finland..........	16,500	
Norway and Sweden	4,943	
Denmark	980	
Germany	21,680	
Holland....................	1,526	
Belgium....................	2,683	
Spain......................	3,972	
Portugal	775	
Switzerland	1,735	
Italy	5,539	
Austria-Hungary	12,147	
Roumania	907	
Bulgaria....................	150	
Turkey in Europe	961	
Greece	7	
		111,186
ASIA AND ISLANDS.		
British India...............	10,832	
Java	312	
Ceylon	178	
Mauritius	92	
Reunion....................	120	
Japan......................	190	
Asia Minor	170	
		11,894
AUSTRALASIA		6,507
AFRICA.		
Algeria	962	
Egypt and Tunis	1,120	
South Africa...............	1,744	
		3,826
AMERICA.		
United States	93,671	
Dominion of Canada	8,805	
Argentine Confederation	1,756	
Uruguay	228	
Parraguay	45	
Chili	1,166	
Peru	1,363	
Brazil.....................	3,043	
Mexico	2,908	
Central American States......	460	
British Guiana	21	
		113,466
WEST INDIES.		
Trinidad....................	44	
Barbados	20	
Jamaica....................	25	
Cuba and Porto Rico	870	
		959
		247,838

The preservation and growth of timber is becoming now a subject of great practical importance in most countries, especially in the United States and the Dominion of Canada, British India, and Australia; and is every year of more and more consequence, from the increasing demand for its use. In European countries, especially in Italy, Germany, Austria, and France, where the climatic injuries resulting from the cutting of timber have long since been rectified, the attention of Government has been turned to the subject by the necessities of the case, and conservative measures have in many instances been successfully applied. A supply of timber has

hence been obtained by cultivation, and other benefits resulting from this measure have been realised. Great Britain, in proportion to its size, is, perhaps, the largest consumer of wood in the world, and her demands are continually on the increase. In 1858, we received about 3,400,000 loads of foreign and colonial wood, of all kinds; last year (1883) we imported over 6,640,000 loads, or nearly double the quantity of a quarter of a century ago. Although the value of the forest products of the United Kingdom are said to exceed £3,000,000 in value, yet our imports of wood are to nearly six times that amount, viz., £17,742,660, in 1883. In 1844, the whole quantity of timber imported into the United Kingdom was under 1,500,000 loads or tons, and the proportions of supply were, one-third from foreign countries, and two-thirds from our Colonies. In 1854, the imports were just upon 2,500,000 loads, of which three-fifths came from our own possessions, and two-fifths from foreign countries. In 1883, out of 6,647,211 loads imported, only a little over 1,529,000 loads came from India and our Colonies. The report of a Parliamentary Committee in 1868 gave the annual average consumption of timber, for our Royal Navy alone, at 20,000 loads, of which about one-fourth was British oak. Now that our war-ships and mercantile marine are no longer built of wood alone, the rate of consumption is necessarily lower.

It has been well observed that in all densely populated countries the consumption of timber is out of all proportion to the natural upgrowth, or even cultural renewal, of indigenous forests, and this disproportion of want to local supply will become greater and greater in the course of time, when denser settlements will be formed in those countries from whence our subsidiary or main timber supplies are now obtained. We are living on a capital which is vanishing rapidly, and we certainly look with inquietude upon the prospects of the future. In Europe, Norway and Sweden have more than 177,000,000 acres covered with trees, mostly, however, of the common kinds, as spruce, fir, pine, &c., and it is but lately that measures have been taken to replace the fellings near the ports, which have become bare of vegetation; it will take time to reap the benefits of this precaution. The total home consumption of Norway was estimated by Mr. Forest-master Scheen in 1884 at 11,481,000 cubic metres. The annual export of timber in the ten years ending 1882 averaged 900,000 tons. In 1881, the exports of timber from the Crown forests of Sweden reached a value of 1,506,883 kronors (£80,382), the largest sum ever reached. The public and private forests amount to about 90,000,000 acres, and 15 years it is stated will see these supplies very materially reduced. Russia, with her 527,000,000 acres of woodland, exports no more timber than the Scandinavian countries, while no sound system of forestry has yet been attempted, except the recent introduction of a few foreign trees. About 3,000,000 tons of wood are annually consumed in St. Petersburg for firewood.

Spain and Portugal, with 6,000,000 acres of woodland, contribute but little to the timber trade of the world, while France, with her 22,000,000 acres, can spare no wood, as she needs every bit for home consumption. Germany has 40,000,000 acres of woodland, and better care is taken for the maintenance of forests there, than anywhere else, and the greatest quantity of the best European timber is produced there. Italy has about 7,000,000 acres of woodland, and exports excellent timber of the finest quality, but not largely.

Turkey and Greece, notwithstanding they have over 10,000,000 acres under forest cultivation, furnish scarcely any timber to the trade of the world. Switzerland and Belgium require more wood than they can produce. The woods and forests of Portugal cover an area of 650,000 acres, of which 600,000 belong to the State, and 50,000 to municipalities; 460,000 acres are covered with pines, and 125,000 with oaks and chestnuts. The largest pine forest is that of Lieria, where the maritime pine abounds. Algeria, with a superficies of 14,000,000 hectares (about 30,000,000 acres), has one-tenth under forests, woods, and coppices.

The Austrian Empire is clothed with forests, (some 45,000,000 acres), which annually furnish 17,000,000 of cubic cords of woods of all descriptions. In some provinces the country is almost wholly covered with trees. Unfortunately, the best kinds are yielded by the most mountainous districts, from whence the difficulty and cost of removal is very great. The wooded districts of Austria comprise 31·7 per cent. of the soil, and from the excellent quality of the timber they furnish to industry species the most varied. The average annual export, from 1872 to 1876, was 181,173 cubic metres of firewood, and 1,749,978 of woods of construction. In 1877, 295,452 cubic metres of the former, and 2,660,711 cubic metres of the latter. There are about 9,300 sawmills at work, 217 of these are worked

by steam, 38 by steam and water, and 9,000 by hydraulic power. The timber sold and employed in the interior of Hungary has been valued at £2,500,000, and the quantity exported at about the same, of which half represents the expense of production, transport, &c.

The oak of Croatia and Sclavonia is of middling quality, greatly inferior to that of Styria and Istria, and principally used in shipbuilding; it is generally exported from Trieste. Beech grows on the slopes near the sea; planks, sleepers for railways, and cask staves are made of it. About 20,000,000 of beech staves are annually exported to France, Spain, and Greece, where they are principally used for flour barrels. Of pine there are two qualities, the most common is the ordinary deal, of which the annual export is 1,500,000 cubic feet; about 3,000,000 cubic feet of two different kinds of deal planks are also exported to France and Algeria. The second quality of pine is exclusively employed for poles and masts.

EXPORT OF TIMBER FROM AUSTRIA.

	Cubic metres.		Cubic metres.
1860	315,747	1870	518,722
1861	428,989	1871	410,958
1862	644,570	1872	489,241
1863	615,578	1873	1,697,419
1864	522,973	1874	1,829,257
1865	529,768	1875	1,913,794
1866	530,615	1876	1,989,498
1867	453,873	1877	2,239,738
1868	532,454	1878	2,129,296
1869	511,591		

According to the latest official returns, the following may be taken as the assumed areas under woods and forests, in the principal countries of Europe:—

	Acres.
Russia in Europe	527,426,510
Norway	18,920,509
Sweden	42,366,000
Denmark	398,877
Holland	527,276
Belgium	1,073,452
France	22,687,716
Italy	9,031,310
Austria proper	23,424,719
Hungary	22,514,450
Spain and Portugal	6,000,000
Germany	40,000,000
Turkey and Greece	10,000,000
Great Britain	2,458,300
Total	726,829,119

The great importance of North America for the future timber supply of the world may be deduced from the fact that Canada possesses almost 1,000,000,000 acres of timber lands, and the United States nearly as much; while the whole surface of the European forests taken together only amounts to about 800,000,000 acres, or less than half of that of North America. But the United States, judging by the declared value of her exports of timber, cannot be looked upon for any continuous supply, the shipments for some few years past having become almost stationary at a little over £3,000,000 sterling in value.

Nothing need here be said about the timber supply of Africa, for of the forests of that continent we at present know but little, except the woods obtained from Algeria, the coast districts of Western Africa, and the South African colonies, which are very limited.

The Australian colonies at present contribute but small supplies to Europe, and the local demand for timber as the settlement progresses is increasing rapidly. The forests of the islands of the Eastern Archipelago will be principally utilised by Holland and Spain. British India and the other parts of Asia, however, furnish useful supplies of wood, and will contribute more as the forests are more easily reached by rivers and roads. The South American forests have as yet furnished but little timber to Europe, except small supplies from Mexico, Central America, and British Guiana. The magnificent forests of Brazil, with their large varieties of wood, have yet to be drawn upon, but at present are for the most part inaccessible to the wants of commerce.

Our supply of foreign woods may be broadly classed under four divisions:—

I. Ordinary soft woods of construction, consisting chiefly of pine and fir, obtained from North America and the North of Europe.

II. Shipbuilding woods, principally oak and teak, with small quantities of greenheart and mora from British Guiana, and a few Australian woods.

III. Hardwoods and furniture woods, which are at present very limited in number, although these might be largely increased by a little enterprise and judgment on the part of the cabinetmakers and dealers.

IV. Dyewoods—These are less important now than formerly, owing to the extensive employment of aniline dyes and the chemical improvements constantly making.

Table showing the Total Imports of Wood into Great Britain in the Past Twenty-five Years:—

Date.	Fir. Hewn loads.	Fir. Sawn or split loads.	Oak. Hewn loads.	Unenumerated Woods. Hewn loads.	Unenumerated Woods. Sawn or split loads
1855	908,515	934,579	...	...	...
1860	1,434,131	1,793,629	...	...	...
1861	1,265,917	1,685,622	82,444	107,809	...
1862	1,146,299	1,530,230	76,743	52,550	22,829
1863	1,257,407	1,863,653	92,520	85,106	27,235
1864	1,223,856	1,944,487	109,710	86,570	31,185
1865	1,396,264	2,085,982	109,305	68,279	44,061
1866	1,231,455	2,165,989	89,161	71,046	14,069
1867	1,018,579	2,163,663	67,885	55,273	7,190
1868	1,100,764	2,401,739	83,543	61,808	7,551
1869	1,099,463	2,322,594	63,997	63,820	1,916
1870	1,209,314	2,644,748	93,660	65,043	1,138
1871	1,453,571	2,615,863	97,412	84,558	241,914
1872	1,551,123	2,810,211	108,789	100,766	283,722
1873	1,816,681	3,117,519	119,199	101,789	316,641
1874	2,146,616	3,486,104	142,717	127,181	354,877
1875	1,508,357	3,015,032	91,394	64,736	290,358
1876	1,904 870	3,759,775	135,951	93,289	358,417
1877	1,848,319	4,209,337	120,118	91,950	377,114
1878	1,532,391	3,274,718	60,254	56,027	368,828
1879	1,254,512	2,914,551	59,061	54,805	341,681
1880	1,910,609	3,795,842	98,499	87,570	320,907
1881	1,674,359	3,335,736	87,881	69,006	337,671
1882	1,812,141	3,831,708	100,327	69,036	366,603
1883	1,905,958	3,951,288	116,262	85,109	364,334

The duty on wood imported was reduced to 1s. per load, in March, 1860, and repealed altogether in 1866.

Russia.—Excepting in the north and north-east, Russia is poorer in forest than the rest of Western Europe. The principal local use of wood in Russia is for house building, for which purpose it is reckoned that 30,000,000 cubic feet are used annually, and these wooden houses must have to be frequently renewed, if the old saying is true, that Russia is burnt down every seven years. Another large employment of timber there is for ship and boat building. It is calculated that about 75,000 vessels of different sorts ply on the inland waters of the Empire, of which about one-fourth are annually destroyed, so that about 15,000 must be built in the year to replace them. The value of the wood exported by land and sea in 1882 was £5,598,120, and that of wood used for fuel was estimated at £13,600,000. Of the total output for 1880, of 2,911,162 cubic fathoms (seven feet), there was set down for timber and fire wood about 617,000,000 cubic feet.

In an official report on Russian forests recently submitted to the Foreign-office, it is stated that about 33 per cent. of the total area of the country may be reckoned to be forest. As compared with this, Austria has 29 per cent. of her area forest; Germany, 26 per cent.; France, 19 per cent.; Italy, 18 per cent; and Turkey, 14 per cent. The amount of wood delivered from the forests of the Crown in Russia averages 600,000,000 cubic feet yearly.

Imports of Wood from Europe, in Loads.

Year.	Russia.		Sweden.		Norway.		Germany.	
	Fir hewn.	Fir sawn.	Fir hewn.	Fir sawn.	Fir hewn.	Fir sawn.	Fir hewn.	Fir sawn.
1866	181,349	433,916	221,621	499,768	106,977	299,393	243,091	59,119
1867	96,615	438,899	185,186	579,010	118,693	339,392	201,198	69,721
1868	108,838	470,513	207,998	704,234	109,736	384,217	217,276	54,930
1869	187,391	481,363	163,460	651,525	104,886	389,634	173,446	25,557
1870	178,002	488,455	238,610	884,702	150,346	438,866	141,361	30,907
1871	187,619	479,575	228,980	906,280	226,197	435,408	297,533	59,757
1872	249,467	590,891	264,928	929,373	228,588	421,146	226,576	56,698
1873	326,004	684,030	355,930	942,912	328,704	399,049	210,874	59,408
1874	479,483	866,531	343,032	943,398	269,377	376,556	327,677	101,709
1875	285,715	773,568	219,144	799,865	212,988	292,362	186,604	78,764
1876	316,350	902,373	297,653	1,054,489	310,012	398,510	203,624	66,579
1877	365,971	1,026,853	283,192	1,185,845	243,615	411,256	167,191	77,290
1878	318,919	798,138	212,063	930,319	248,394	329,574	186,918	79,983
1879	171,574	625,675	182,720	944,661	247,069	257,203	173,996	63,378
1880	331,012	966,573	308,702	1,066,391	338,943	366,400	225,964	63,973
1881	224,421	822,864	274,223	908,475	313,948	329,276	178,601	68,642
1882	294,065	1,063,200	283,162	1,088,392	316,887	367,070	251,152	72,184
1883	280,490	1,075,574	299,807	1,291,975	331,111	424,571	350,075	78,045

England takes 40 per cent. of the wood exported, and Germany 35 per cent., of which a good deal is in transit for England. Holland takes 10 per cent., and other countries smaller amounts.

Our imports of timber of all kinds from Russia have been as follows, in tons:—

Year.	Hewn.	Sawn or split.	Hard wood. un-enumerated.
1862	100,340	291,457	..
1863	109,908	330,904	..
1864	129,950	379,452	..
1865	211,418	461,844	..
1866	191,855	483,791	..
1867	106,123	438,878	..
1868	118,577	470,489	..
1869	196,143	481,693	..
1870	184,323	539,272	905
1871	191,005	516,377	2,101
1872	257,656	632,479	5,734
1873	388,003	754,933	4,316
1874	496,270	958,355	1,364
1875	292,797	843,613	4,317
1876	325,958	1,005,647	6,160
1877	373,931	1,173,612	433
1878	321,735	920,276	3,175
1879	174,307	723,639	317
1880	336,132	1,062,008	293
1881	227,243	929,670	933
1882	297,485	1,179,938	2,688
1883	272,046	1,075,186	5,031

Canada.—Our imports of wood from Canada do not as yet show any material decline, although there are yearly fluctuations arising from the condition of trade, but the following remarks, which appear in the annual report of the Secretary of the Montreal Board of Trade for 1882, are worthy of attention:—"While the increasing demands of commerce are causing the timber forests of Canada to be cut down at a sweeping rate year after year, no protection from fire is enforced by the Government; there has been but a feeble cry raised for the conservation of the forest patrimony of the Dominion; there is no planting and no protection for young trees. Unless this record is speedily reversed, future generations will have good reason to blame their progenitors for their imprudent, even prodigal mismanagement."

Since these observations were made, I learn that the Government of the province of Ontario has taken up seriously the question of preserving and replanting forests, and of tree planting on the high roads and farms. The Government of Quebec has also woke up to the importance of the subject, and has instituted, like the States, an "arbor" day, or annual tree-planting holiday throughout the province.

Our imports of different kinds of wood from Canada in the last twenty-two years have been as follows, in loads:—

Year.	Hewn.	Sawn or split.	Staves.	Furniture and hardwoods.
				Tons.
1862	465,126	209,960	18,564	1,363
1863	652,837	273,877	24,509	2,474
1864	642,541	236,518	19,191	2,406
1865	613,105	317,636	19,325	1,463
1866	505,763	298,599	25,252	1,567
1867	421,132	243,397	20,451	909
1868	496,702	768,652	21,964	3,263
1869	438,942	751,226	18,329	2,756
1870	466,681	776,921	22,004	4,526
1871	460,239	702,305	27,172	3,302
1872	449,683	788,239	17,285	2,672
1873	371,109	971,359	21,561	2,431
1874	476,451	1,089,550	18,980	2,569
1875	340,428	958,183	12,041	2,394
1876	477,748	1,127,291	19,448	4,461
1877	490,590	1,262,825	18,457	2,949
1878	265,340	968,155	9,678	1,676
1879	198,009	907,634	8,498	2,384
1880	372,986	1,172,323	6,455	4,328
1881	302,484	998,817	5,542	3,633
1882	280,322	1,029,360	7,393	3,290
1883	343,170	1,182,263	8,830	5,106

The lumber industry of Canada has long been depressed and overstocked, but the quantity of timber cut last year is much less than the previous season. The cut of pine and spruce will be less by at least 1,000,000 feet. From Ontario, nearly the whole of the timber goes to the United States. In 1882, the trade in lumber alone with the United States amounted to over £2,000,000. The value of the forest exports of the Province of New Brunswick in 1882 was stated at over £600,000. At the expiration of ten to fifteen years, all the large and soft wood lumber there will be exhausted, and the manufacturers of lumber will have to fall back on second growth and small woods for the supply of their mills. The cut of timber on Government lands in New Brunswick equals 160,000,000 feet.

The province of Quebec has under license 48,500 square miles, producing in all 549,976,000 feet of timber. That of Ontario has 181,000 square miles under license, producing in all 635,500,000 feet B.M. These figures are for the years 1880-81. The quantity of timber required for home consumption or domestic use in the Dominion is estimated at two-thirds

of the total quantity made. There are ninety-five species of forest trees in Canada, of which Ontario, the most southerly of the provinces, has 65. British Columbia is amply supplied with timber, and as its facilities for export increase, it must develop a large trade.

The coast line of British Columbia, both on the inland and mainland, is clothed with the finest timber. The Douglas pine, with its straight uniform trunks, often 200 feet high, and exceedingly tough and flexible, furnishes the finest masts and spars for the largest vessels.

Table giving the Principal Wood Exports from Canada (Upper and Lower Canada only up to 1867. After 1863, the years ending 30th June, for the Dominion), in loads.

Year.	Elm.	Oak.	White Pine.	Red Pine.
1850	38,272	30,446	372,742	89,996
1851	35,644	40,977	453,435	91,145
1852	23,372	30,418	423,617	63,105
1853	28,933	38,790	468,416	70,483
1854	37,621	37,525	516,430	67,847
1855	26,191	29,558	287,487	57,884
1856	36,453	33,814	361,046	61,943
1857	37,984	48,539	500,781	61,323
1858	19,451	26,904	344,981	53,143
1859	26,278	34,300	395,694	43,643
1860	25,629	41,553	490,233	62,573
1861	32,610	55,979	523,112	71,381
1862	27,689	57,436	430,257	65,663
1863	53,392	73,327	650,483	103,329
1864	55,431	76,809	563,981	109,575
1865	49,048	118,313	606,300	108,877
1866	29,483	64,026	450,950	85,638
1867	28,476	62,895	413,036	78,792
1868	33,657	63,841	439,007	65,952
1869	35,965	67,954	418,302	56,860
1870	33,498	68,659	365,068	45,301
1871	27,456	94,751	352,154	50,225
1872	23,431	88,712	428,259	45,534
1873	22,401	83,174	373,410	40,959
1874	26,696	90,425	252,920	20,534
1875	26,629	81,959	319,173	44,056
1876	20,940	66,952	289,441	37,040
1877	26,919	97,766	413,787	56,540
1878	20,405	72,363	303,801	37,453
1879	8,648	28,647	129,161	20,662
1880	14,578	43,606	148,961	19,911
1881	28,905	67,161	334,153	37,445
1882	22,830	47,802	213,999	25,843
1883	...	...	...	...

The average area of timber lands in the Dominion of Canada is about 280,000 square miles.

The other woods shipped from Canada in 1881 and 1882, were as follows, in tons:—

	1881.	1882.
Maple	197	788
Ash	9,302	8,202
Birch	361,655	25,355
Square timber	9,809	6,294
Deals (standard hundreds)	260,305	263,594

The exports of Canadian timber by sea are chiefly to Britain, and embrace square timber, staves and deals. The timbers consist of oak, elm, ash, birch, maple, tamarac, and white and red pine; the deals are both pine and spruce. Some timber is, however, shipped to the States, to South America, and the West Indies.

Exports, produce of the Forest, Dominion of Canada in the years ending June:—

	Value in dollars.		Value in dollars.
1855	7,947,923	1873	28,586,816
1866	11,012,053	1877	22,765,900
1869	19,838,963	1882	23,991,055
1870	18,262,170	1883	26,648,441

United States.—In North America, the forests of the Northern States are being rapidly exhausted, but the Southern States offer a supply of timber vast in quantity, cheap in price, and of almost endless variety.

The magnitude of the forest products of the United States is shown by recent statistics. The value for 1883 was set down at 140,000,000\$. By far the largest proportion is used as timber. The value of the wood employed annually in cooperage was stated in the last census at 33,714,770\$. Several million dollars' worth are annually consumed in the manufacture of baskets. The lucifer matches consumed in the States require wood to the value annually of 3,298,562\$.

The chief of the Forestry Division of the Bureau of Agriculture, states, that 2,999,542 cords of bark were used in tanning in 1880, at an average cost of 6\$ per cord, which would bring the aggregate value of bark up to 17,456,252\$. This does not include the value of trees cut for bark and left to decay.

It has been well remarked by the Minister of Agriculture of the United States, that "although in some instances the consumption of timber may become less, as from the substitution of iron in civil and naval architecture, or of mineral coal for fuel, we can scarcely expect that the general demand will ever decrease, but that it will steadily advance with our increase in wealth and numbers, and as native timber is exhausted, it must in a great degree be re-reared under the care and protection of man."

Timber Exports from the United States.

	Value in dollars.		Value in dollars.
1860	4,700,805	1864	14,696,340
1861	5,974,671	1865	15,544,163
1862	8,123,773	1866	12,856,171
1863	9,929,130	1867	13,060,942

	Value in dollars.		Value in dollars.
1868	12,501,174	1875	18,440,000
1869	11,398,407	1876	17,296,000
1870	13,735,000	1877	18,444,000
1871	12,942,888	1878	16,776,000
1872	15,241,000	1879	15,625,000
1873	19,120,000	1880	16,237,000
1874	21,354,000		

Our direct imports of wood from the United States have been as follows :—

Years.	Hewn.	Sawn or split.	Staves.	Furniture and hard-woods.
1862	4,072	61,462	6,017	1,762
1863	2,938	45,867	10,005	2,282
1864	20,280	38,304	7,532	3,504
1865	16,700	22,327	5,737	6,826
1866	39,398	14,676	7,499	3,383
1867	45,700	14,020	6,081	2,430
1868	58,336	17,834	4,869	2,233
1869	92,324	22,672	7,668	2,497
1870	96,490	18,851	5,586	1,200
1871	117,621	42,045	6,527	2,514
1872	162,635	47,952	8,028	6,231
1873	182,547	70,798	12,161	6,535
1874	302,325	129,640	7,157	6,000
1875	155,181	123,736	7,569	11,641
1876	212,588	224,291	11,070	9,313
1877	175,232	261,975	12,208	9,195
1878	122,625	179,223	14,352	7,570
1879	95,823	132,139	11,711	9,586
1880	140,245	181,675	11,590	11,521
1881	155,737	229,268	17,731	19,997
1882	155,599	237,741	23,852	20,248
1883	112,987	241,684	21,871	27,091

Many of our colonies draw supplies of wood from ports in Great Britain, besides other quantities which they import direct from Europe and America. A good deal of soft wood goes to Australia. Our shipments to Victoria increased from 8,337 tons in 1876, to 14,030 tons in 1882, and 9,567 in 1883. To South Australia we sent 9,031 loads in 1881, and 6,502 loads in 1882, and last year only 1,535; to Tasmania 1,186 tons in 1883; to New South Wales 8,744 loads in 1882, and 3,367 in 1883; to India 1,501 loads in 1882, and 41,655 in 1883. To the Cape Colony our wood shipments rose from 5,600 loads in 1878 to 15,076 loads in 1882 (besides a few hundred loads of staves), and were 5,471 loads in 1883.

Having taken a survey of the chief sources of wood supply in Europe and America, we may now pass on to investigate the wood production of India and the Australasian colonies.

INDIA.—The area of demarcated forest reserves in India, at the close of the official year, March 1883, was 49,059 square miles against 10,003 square miles in 1873-74. Of these forest reserves 2,176 are in non-British territory, viz., Mysore and Berar.

The higher slopes of the Himalayas in Kashmir and Nepal, the hills in the country just beyond our western Punjab frontier, and those prolonging the Himalayan chain eastward to South-western China and Siam, are clothed with the most magnificent forest vegetation, and are capable of supplying unlimited quantities of the best kinds of timber.

Where water carriage exists, as it does in Kashmir, Nepal, and Burmah, the trade can be conducted on a large scale, the cost of transport being inappreciable, as the logs are floated down the streams; but where such water carriage is not to be had, these grand forests are for the present locked up and inaccessible. We have, it is true, those vast forests in India, but until of late years little attention was given to their due preservation by the Government.

In Scinde, Malabar, Canara, Mysore, Travancore, Burmah, the Tenasserim Provinces, the wooded tracts which skirt the base of the Himalayas, and the islands of the Indian Archipelago, there are large supplies of valuable wood yet to be utilised, so soon as facilities of conveyance to the coast can bring them within easy access. The same may be said of British and French Guiana, Brazil, and other States of South and Central America.

Some Australian hardwoods, such as iron-bark, are admitted by Lloyd's only into the ten years' classification of woods suitable for the timbering of ships, whilst Mora is placed in the twelve years' grade; and yet reliable tests give to the former as good a character as the latter for durability. Jarrah, another valuable Australian ship-building wood, is also ignored. These are examples of many instances where scientific inquiry and prolonged experience are essentially necessary.

The wood exports from India consist chiefly of teak and sandal-wood, The following table gives an idea of their importance. (The official years in India end in March).

EXPORTS FROM INDIA.

Years.	Teak to United Kingdom only.	Other woods.	Sandal-wood.	Ebony.	Other ornamental woods.
	Tons.	Tons.	£	£	£
1877-78	49,339	1,295	36,306	356	160
1878-79	29 479	2,348	30,778	1,581	814
1879-80	26,657	1,058	37,995	891	193
1880-81	58,715	1,002	26,588	1,091	178
1881-82	48,989	1,273	39,828	937	6,213
1882-83	50,231	1,082	40,293	54	356
1883-84	27,556	1,274	25,534	197	1,188

The imports of timber into Burmah by the Irrawaddy, Siam, and the Northern Shan States, were, in 1878, 213,052 tons; 1879 220,014; 1880, 109,192; 1882, 137,112; 1883, 180,208. The value of the timber (principally teak) exported from British Burmah in the last twenty-three years has been as follows:—

Years.	£	Years.	£
1861-62......	392,751	1872-73......	322,370
1862-63......	221,817	1873-74......	350,951
1863-64......	156,560	1874-75......	292,127
1864-65......	378,146	1875-76......	395,815
1865-66......	283,268	1876-77......	297,271
1866-67......	91,618	1877-78......	353,753
(11 months only)		1878-79......	212,518
1867-68......	91,929	1879-80......	200,133
1868-69......	246,258	1880-81......	452,011
1869-70......	94,489	1881-82......	445,302
1870-71......	190,080	1882-83......	517,881
1871-72......	238,351	1883-84......	1,126,937

The last year includes all the exports coastwise.

The exports of teak from India (although there are necessarily fluctuations in the shipments) does not show any great decrease; the average yearly exports may be taken at 55,000 tons. The following figures give the total shipments and Indian valuation for a series of years. The bulk of the exports come to the United Kingdom.

TOTAL EXPORTS OF TEAK FROM INDIA.

Years.	Cubic tons.	Indian valuation. £
1874-75	42,868	—
1875-76	60,612	—
1876-77	45,108	—
1877-78	56,962	406,652
1878-79	37,487	268,958
1879-80	38,622	281,960
1880-81	65,642	500,046
1881-82	56,377	506,791
1882-83	59,198	611,260
1883-84	46,471	525,447

Our imports of teak into the United Kingdom, as given in the Board of Trade returns, have been as follows:—

Years.	Loads.	Years.	Loads.
1866	35,724	1875	30,533
1867	12,644	1876	35,266
1868	18,888	1877	28,072
1869	40,062	1878	37,990
1870	17,038	1879	15,737
1871	23,353	1880	33,863
1872	28,898	1881	40,720
1873	40,513	1882	41,152
1874	30,011	1883	45,539

The imports of teak into Liverpool last year were much about the same as the average of the five years ending 1877, viz., 244,000 cubic feet. The quantity received in the port of London, was in—

Years.	Loads.
1880	5,800
1881	14,400
1882	6,700
1883	9,800

The supply of teak is of sufficient importance to warrant special attention, and I propose reading a paper on it before the Indian Section of this Society next month.

In India proper, there are but few sawmills, viz., two in the Madras Presidency, two in Bombay, and two in Assam, but in British Burmah there are thirty-eight. The total value of the timber shipped from India is shown in the following official figures; four-fifths being the value of the teak:—

Years.	£	Years.	£
1873-74......	415,904	1879-80......	340,144
1874-75......	366,399	1880-81......	545,853
1875-76......	471,627	1881-82......	566,717
1876-77......	373,878	1882-83......	674,477
1877-78......	458,792	1883-84......	579,937
1878-79......	321,868		

Sandal-wood.—The revenue derived from sandal-wood in the State forests of Mysore is very large, it having been a Government monopoly for 50 years. The tree springs up from self-sown seed, and grows luxuriantly in many parts. The cuttings were formerly restricted to 500 tons of growing trees, but in 1878 this was extended to 1,000 tons extra, making 1,500 tons in all. The surplus revenue was:—

Years.	Surplus.	Total Receipts.
1833-43	12,789	14,679
1843-53	14,568	16,745
1853-63	17,558	29,852
1863-73	23,147	34,240

In 1878-79, the sales in Mysore were 1,080 tons, at an average of nearly £34 a ton. In the following year 1,396½ tons were sold, at £35 a ton, bringing in a net profit of £39,431. The marked maturity of the tree is judged to be as soon as possible after the formation of the heart-wood. The crop value of a fully stocked sandal plantation, cut at 40 years, supposing it at that time to contain 100 mature trees per acre, of a net value of £3 each, will be £300 per acre. The demand for sandal-wood in Europe is inexhaustible, but it is chiefly sent from Bombay to China, where it is used for ornamental work of various kinds.

Indian blackwood (*Dalbergia latifolia*), generally called rosewood among timber merchants and workmen, is used for furniture; but it is not much in demand. There are plenty of trees of it in the forest of Mysore. The wood is sound and runs large, so that excellent slabs and planks can be got from it. From Siam, 37,217 piculs (of $1\frac{1}{4}$ cwt.) of this blackwood were shipped in 1870. In 1882, ornamental Indian woods to the value of £78,281 were sent to various Presidency ports, chiefly Bombay. What is known as Moulmein cedar is the Toon wood of India (*Cedrela toona*), universally used there for furniture of all kinds. It fetches in Burmah about £6 a ton. If sent in well squared hewn logs, about 15 inches square and 12 feet and upwards in length, it would fetch nearly 3s. a cubic foot, as a substitute for mahogany. In Bengal, Assam, and Burmah, it grows to a very large size, trees, 20 feet girth, with a height of 80 to 140 feet of clear stem, being not uncommon in forests which have been little worked, like those in Dumsong and some parts of the Chittagong hill tracts.

If it can be delivered in any large quantity at Chittagong, or some Burmese port, it might be profitable to send shipments to London, though exports from the forests of Northern India are out of the question. The Sal timber (*Shorea robusta*), for which Bengal has been so famous, exists largely in most of the forest areas. In past days there was much unnecessary destruction and irreparable waste of these trees, and it may be doubted whether the timber resources of the country are now equal to its prospective demand. The Soondri trees (*Heritiera sp.*) of the Soonderbuns furnish the best wood for the boats which are built in such great numbers throughout Eastern Bengal. Time would fail to permit me entering into detail on other Indian woods.

CEYLON.—The timber trade of this island ought to keep up and increase in importance for a long series of years to come. Their extensive forests, of the more valuable kinds of wood, are as yet practically untouched in the central province, and a proper system of conservation ought to render them comparatively permanent sources of revenue to the colony. The exports of timber and dye-woods from this colony have been as follows in value :—

	£		£
1850	12,195	1879	40,907
1860	20,219	1880	..
1865	19,565	1881	..
1870	27,212	1882	26,000
1874	38,264	1883	33,414
1878	32,121		

These exports consist chiefly of ebony, sappan wood, satin wood, and sandal wood. Wood to the value of about £9,000 is imported.

As we have nothing to look for in the supply of woods from Mauritius and the African colonies, we may pass on now to glance at the wood products and prospects of Australasia.

VICTORIA. — The approximate area occupied by forest trees in Victoria (exclusive of about 14,000 square miles covered with "Mallee scrub," which consists of dwarf eucalypti, tea tree, &c.), is about 40,000 square miles. This consists nearly all of the indigenous eucalypts. The large white and red gums (*E. amygdalina* and *E. rostrata*) covering 8,000, stringy bark (*E. obliqua*) and messmate 25,000 square miles. Special reserves have been made by Government of heavily timbered lands, amounting to about 1,000,000 acres.

Victoria imports much more timber than she exports, as the following official figures will show. The imports are principally soft woods, in which the colony is deficient :—

	Value of Imports. £	Value of Exports. £
1864	318,122	..
1865	271,848	..
1866	341,203	..
1867	217,739	10,452
1868	207,764	..
1869	274,497	..
1870	228,098	4,666
1871	172,803	10,554
1872	301,831	8,966
1873	588,498	10,194
1874	478,403	27,054
1875	452,471	59,596
1876	324,189	36,191
1877	536,761	42,181
1878	533,626	51,003
1879	318,187	57,617
1880	261,900	49,300
1881	51,695	40,560
1882	715,420	49,306
1883	706,424	43,172

NEW SOUTH WALES.—The reported area of woods and forests under the care of the conservator in this colony, amounted, in 1881, to 3,759,796 acres, and the timber cut from them during the year was stated at 3,923,727 feet, from which a revenue of £10,156 was derived.

There are numerous varieties of valuable hardwoods in this colony, useful for every description of ship and house building, furniture, carriage building, and many othe purposes.

Mr. Chas. Moore, the Colonial botanist, well observes, that "no country has been favoured by nature with a greater variety and abundance of trees yielding strong, beautiful, and durable timbers than the colony of New South Wales." The banks of the coast rivers are supplied with a luxuriant growth of both kinds. There are twenty-seven species of eucalypts alone. The durability of the New South Wales timbers is proved by the fact that the vessels built in the colony never seem to grow old. Some descriptions of wood placed in wells and buried in the ground have been taken up after the lapse of 50 years and upwards, and found to be as sound as on the day they were immured or immersed. The best timbers are found near water carriage, and the rivers along the coast all offer superior facilities for shipbuilding, timber as sound and durable as any yet known, being there ready to hand.

Of the ten thousand forest trees which probably represent the timber-producing capabilities of the globe, seven or eight thousand would flourish in New South Wales. Already there is an export trade in cut and sawn timber of considerable value. The export in 1881 was valued at £23,816, in 1882 at £42,040, and in 1883 at £67,150. It was well observed by the Jurors on Wood at the Victoria Exhibition of 1872, that the disfavour which attaches to Australian timber is in a large measure owing to the fact that the timber is so frequently felled at improper seasons, whilst the sap vessels are full; and it is a matter for regret that this is never considered by the Government in calling for tenders; the completion of the work being often stipulated for at a time which leaves the contractor no alternative but to fell his timber after the sap has risen. Another cause of the disfavour is owing to the fact that due care is not exercised in sending the best sorts, besides which there is a general want of care in withdrawing faulty pieces from shipment,

The following figures show the shipments of colonial timber from New South Wales (exclusive of re-exports):—

	Superficial feet.
1871	4,108,398
1872	4,641,150
1873	6,223,940
1874	5,361,778
1875	6,871,900
1876	3,515,200
1877	3,102,029
1878	4,096,802
1879	4,880,437
1880	2,015,180
1881	4,125,896
1882	5,834,762
1883	8,829,754

But the imports of timber are far larger than the exports, reaching, in 1883, 47,565,000 superficial feet, and with other wood valued at £403,547.

Upwards of 70 specimens of woods of the colony were officially tested by Colonel Ward, R.E., at the Mint, Sydney, in 1861, at the request of Sir William Denison, and the results showed that for strength, durability and elasticity, many of the woods were superior to the ash, the oak, and the best woods of Great Britain. A Sydney shipowner of long experience furnished a list (which will be found on the next page) of timbers suitable for shipbuilding purposes, with their uses and probable duration, and also many instances of vessels which have been sailed from 15 to 30 years, whose hulls, made of colonial hard wood, are as sound as ever:—

It is impossible here to enumerate or describe even the principal woods of this colony.

The flooded gum is remarkable for its durability as a shipbuilding wood; specimens taken from a steamer plying incessantly for twenty years, were as sound throughout as when built.

Black iron-bark (*Eucalyptus leucoxylon*) is a wood of great merit for strength and durability, very hard and of good colour, but enormously heavy. It is very useful to the coachmaker and wheelwright, and is also valuable for many purposes in shipbuilding. The blackwood (*Acacia melanoxylon*) is a magnificent wood for every description of cabinet work, as it has a beautifully marked richly-coloured grain, which takes a polish freely, and gives an effect not even surpassed by walnut, to which it has many points of similarity. It is very close grained and heavy, and is useful for all purposes where lightness, combined with strength and flexibility, are required. It is largely used by coachbuilders in the colony in every department of their trade. Tulip wood (*Harpullia pendula*) is a large tree, 50 to 60 feet high, with a diameter of 14 to 24 inches. The timber is very strong, beautifully marked with different shades, from black to yellow. It takes a good polish, and is much esteemed for cabinet work.

Honeysuckle (*Banksia serrata*) is a good available wood for boat and ship building purposes, not being likely to split with nailing. It is used for veneers, &c., and would make

Common names.	Scientific names.	General use.	Duration.
Ironbark	*Euc. sideroxylon*	Ships' keels, stern-posts, and lower timbers	Over 50 years.
Grey box	*Euc. saligna*	Keels, sterns, stern-posts, kelsons, clamps, beams and knees, and planking	Over 50 "
Spotted gum	*Eu. maculata*	All framework, planking and lining	40 "
Black butt	*Eu. pilularis*	Lower masts, planking and all scantling	40 "
Blue gum	*Eu. globulus*	Planking and scantling, top timbers	30 "
Flooded gum	*Eu. rostrata*	All spars and planking	30 "
Bangally	*Eu. botryoides*	Planking and timbers	Over 40 "
Forest mahogany	*Eu. resinifera*	Upper and lower timbers	40 "
Swamp "	*E. robusta*	" " "	40 "
Woolly butt	*E. longifolia*	Timbers and planking	Over 40 "
Tallow wood	*E. microcorys*	Keels, sterns, stern-posts, kelsons, knees, beams, dead woods, and all framework	Over 50 "
Apple tree or white gum	*E. stuartiana*	Planking and all framework	Over 40 "
Turpentine	*Syncarpia albino*	Keels and all parts under water	Over 40 "
White beech	*Gmelina Leichardtii*	Deck planks and cabin fittings	Over 15 "
Cedar	*Cedrela toona*	Top timbers, cabin fittings, boat planks	Over 15 "
Mountain pine	*Callitris cupressiformis, or Fresnelia rhomboidea*	Deck planks, bulwarks, cabin fittings, boat planks	Over 15 "

good furniture. The wood is of a dark red colour, and takes a good polish.

QUEENSLAND.—The timbers of this colony are as valuable for their variety and uses for commercial purposes as those of the adjoining colony of New South Wales. Irrespective of the immense home consumption, there is a large export trade in cedar logs and pine, ranging now in value from £30,000 to £60,000, as the following statistics of the timber exports will shew:—

	£		£
1860	2,442	1872	20,079
1861	2,629	1873	27,196
1862	3,066	1874	26,616
1863	5,482	1875	26,884
1864	8,039	1876	36,979
1865	8,383	1877	35,629
1866	13,625	1878	56,233
1867	17,802	1879	74,012
1868	16,578	1880	42,611
1869	30,241	1881	51,454
1870	19,937	1882	30,627
1871	20,216	1883	25,676

The hardwoods in the timber producing districts of this colony, are not only in great variety, but at present, so far as can be estimated, are in full supply. There are still extensive scrubs of the red cedar (*Cedrela toona*) in the colony, especially in the districts north of Cardwell. Of late years there has been a wholesale destruction of this valuable timber, and in view of the supply failing, the Government have lately passed a law having for its object the conservance of this timber, and that of the State forests generally.

It is strange that with the demand and the deficient supply of cedar wood, more logs of Australian cedar are not imported here. The tree, which grows to a height of 100 to 150 feet, with a diameter ranging from three to seven feet, furnishes the best known and perhaps the most valuable wood in New South Wales and Queensland. It is easily worked, and in dry situations is very durable. Some trees have been cut on the Richmond river yielding 30,000 feet of saleable timber. The junction of the branches with the stem furnish those beautiful curled pieces of which the choicest veneers are made. The root stock is also much valued by cabinet makers for veneering purposes. It is an article of great commercial importance, and the wood is largely exported from Queensland to the other colonies. The market value there is from twenty shillings per hundred superficial feet, according to colour and size. This wood can yet be obtained in considerable quantities, but will soon become a scarce article, as it is not to be procured of any size from other localities than those indicated, viz., open forest bushes on the coast of New South Wales, on the Richmond, Bellinger and Tweed rivers. In 1870, a few logs were sent to Great Britain, and in the four

following years about 222,300 feet of sawn cedar. In 1881 and 1882 a few logs were received in London, and being of good size and sound, realized high prices, 4d. to 5d. per foot.

The cypress pine (*Fresnelia rhomboidea*) is another Queensland tree, attaining a height of fifty to seventy feet, with a diameter of twenty to forty inches. The timber is an article of great importance, being durable, fine-grained, fragrant, and capable of a high polish. It is used for piles for wharves and sheathing boats, resisting the attacks of the *Teredo navalis* and *Termites*. The root is valued by cabinet makers for veneering purposes. The market value of this wood in the colony is 10s. per hundred superficial feet.

The brush or bastard box (*Tristania conferta*) grows to a height of eighty to one hundred feet, with a diameter of four to five feet. It furnishes a valuable timber on account of its great durability and immunity from white ants. As ribs of vessels, it has been found perfectly sound at the end of thirty years.

Beef wood and swamp oak (*Casuarina torulosa*, and *C. equisitifolia*) give woods close grained and beautifully marked, and furnish handsome veneers. Rosewood (*Dyoxylon Fraseranum*) is a beautiful wood, dark, hard, close-grained, fragrant, and, when properly seasoned, capable of being worked into the best kind of furniture, and is useful in turning.

Myall (*Acacia homalophylla*) is a dark, close-grained wood, well adapted for cabinet-making purposes, but it is not of large size. There are several kinds of sandal wood in this colony. The timber of *Exocarpus latifolia* is very hard and fragrant, and excellent for cabinet work. That of *Santalum lanceolatum* is close-grained and takes a good polish. Both these trees are from fifteen to twenty-five feet high, with a diameter of six inches. The timber of the bastard sandal wood (*Eremophila Mitchelli*) is hard, beautifully grained, very fragrant, and makes handsome veneers for cabinet work. The tree grows to twenty to thirty feet high, with a diameter of six to twelve inches.

Cabinet makers are so accustomed to mahogany, and a few other woods, that they are reluctant to introduce any new variety, except under special circumstances.

TASMANIA.—There are about 4,000,000 acres of heavily wooded land in this island. The export trade is almost exclusively confined to the adjoining colonies, and the imposition of protective duties in Victoria has naturally interfered with the shipments there; these are now confined almost entirely to palings and to small consignments of the musk wood and the beautifully marked Huon pine. There are more than 34 sawmills in this island. The following shows the value of the timber exported from Tasmania:—

Year.		£	Year.		£
1854	......	308,857	1869	......	42,617
1855	......	98,547	1870	......	37,267
1856	......	112,753	1871	......	49,540
1857	......	133,953	1872	......	46,614
1858	......	109,811	1873	......	63,246
1859	......	84,122	1874	......	75,422
1860	......	73,535	1875	......	88,645
1861	......	55,850	1876	......	65,151
1862	......	66,659	1877	......	72,909
1863	......	70,521	1878	......	72,989
1864	......	—	1879	......	59,713
1865	......	56,698	1880	......	51,973
1866	......	45,731	1881	......	56,605
1867	......	54,747	1882	......	52,748
1868	......	49,480			

SOUTH AUSTRALIA.—We can expect no supplies from this colony, as the indigenous timber is being fast exterminated, but planting is being carried on. About 20,000 loads of sawn timber are imported annually, besides a large quantity of shingles and laths,

WESTERN AUSTRALIA is very rich in good timber, which is now being largely developed. The forests of Western Australia cover an area as large as Great Britain. There are more than 30,000 square miles covered with eucalyptus, 24,000 miles of which consist of the white gum (*E. viminalis*) and jarrah (*E. marginata*). The latter is a most important shipbuilding wood from its imperishable nature and immunity of attack from insects. The tooart (*E. gomphocephala*) and red gum (*E. calophylla*) are also excellent woods. The scented sandal wood (*Santalum cygnorum*) has for some years contributed largely to the productive industry and profit of Western Australia, but unless new plantations are formed, it cannot very long continue to do so, as the distance which even now it has to be carried to the ports of shipment raises its price so much as to leave no great margin of profit. A scentless sandal wood (*S. persicarum*), called locally manibou, is very plentiful in the colony, and from the fineness of the grain of the wood, might be made use of for wood engraving.

There are about 12 saw mills in the colony, of which the most important are the Jarrahdale Company, of Rockingham, with a railway to

the port 23 miles long, employing nearly 200 hands; the Western Australian Jarrah Company, at Lockville, with 16½ miles of tramway; Davie's Karridale saw-mills at Augusta and Port Hanelin, with 6 miles of tramway, and employing 100 to 150 men; and the Canning saw-mill, with 8½ miles of tramway, employing about 50 men.

The following table gives the value of the two principal kinds of timber exported for a few years:—

	Sandal wood.	Jarrah.
	£	£
1864	24,520	5,508
1865	13,490	15,693
1866	23,722	6,849
1867	18,442	4,541
1868	26,045	638
1869	32,998	14,274
1870	48,890	17,571
1871	26,926	15,304
1872	31,536	2,590
1873	62,916	4,770
1882	96,080,	9,605 tons, at £10 a ton.
1883	56,250,	7,031 tons, at £8 a ton.

The quantity of jarrah shipped from Western Australia, chiefly to the neighbouring colonies, was as follows:—1879, 12,545 loads; 1880, 13,250½ loads; 1881, 15,855½ loads, valued at £79,277 10s.; 1882, 18,730 loads, valued at £93,650, £5 a load; 1883, 19,940 loads, valued at £79,760, £4 a load.

Of the last quantity, 14,075½ tons went to South Australia, 743 tons to India, 681 to Victoria, and 356 to New Zealand. The value of the timber shipped in 1882 including sandal wood was £189,700.

New Zealand.—An estimate of the forest land in this colony, made in 1873, gave the following returns:—

	Acres.
North Island	6,050,000
South Island	6,080,000
Total	12,130,000

This area has, however, been much diminished in the last ten years.

The indigenous forest of New Zealand is evergreen, and contains a large variety of valuable woods. The general character of these much resemble the growths of Tasmania and the continent of Australia, most of them being harder, heavier, and more difficult to work than the majority of the European and North American timbers.

Many of the more valuable trees of Europe, America, and Australia have been introduced, and flourish with a vigour scarcely ever attained in their native habitats.

The New Zealand woods vary very much among themselves. Many varieties are very durable—manuka (*Leptospermum ericoides*), totara (*Podocarpus totara*), kauri (*Dammara australis*), black birch (*Fagus fusci*), kowhai (*Sophora tetraptera*), and matai (*Podocarpus spicata*) appear to be the most useful and highly esteemed.

Manuka.—This timber can be had from 28 to 30 feet long, and 14 inches diameter at the butt, and 10 inches at the small end. The old timber, from its dark-coloured markings, might be used with advantage in cabinet work, and its great durability recommends it for many other purposes. It is highly valued in the colony for jetty and wharf piles, as it resists the marine worm better than any other timber found there.

Birch Totara (*Podocarpus totara*) is a most useful timber for commercial purposes. It is found as a lofty and spreading tree, 60 to 120 feet high, and nearly five feet in diameter. The wood is very durable and clean-grained, in appearance like cedar, and works with equal freedom. It is used extensively for house building, piles for native wharfs and bridges, and railway sleepers, &c.; when felled during the growing season, the wood resists a longer time the attacks of the *teredo* worm. The Maoris make their largest canoes from this tree.

Kauri.—This is the finest forest tree of New Zealand, and attains a height of 120 to 160 feet. The trunk is sometimes 80 to 100 feet high before before branching, and attains a diameter at the base of 10 to 20 feet. The timber is in high repute for masts and spars, deck and other planking of vessels, railway sleepers, and house finishing. There is evidence of its durability for more than 50 years in some of the old mission buildings at the Bay of Islands, and other constructions. It forms the bulk of the timber exported from New Zealand, but only grows in the North Island. It makes a rich and valuable furniture wood, some of the largest and soundest kauri timber having richly mottled shading.

On an average the kauri pine may be estimated as yielding, when sawn into conveniently sized boards, between 6,000 or 7,000 feet of timber. The annual cut of this timber is about 110,000,000 feet. The trees cover about 180,000 acres, and the estimate of the timber is set down at 23,000 million feet.

The *Tawhai*, or black birch, is a noble tree,

from sixty to ninety feet high, with a trunk five to eight feet in diameter. The timber is excessively tough and hard to cut, but highly valued, as being both strong and durable in all situations.

Kowhai.—This is a small, or middling sized tree, with a red wood, which, being highly durable and abundant throughout the islands, is used for piles in bridges, wharves, &c. It is also adapted for cabinet work.

Matai, or black pine.—A large tree, 80 feet high, trunk two to four feet in diameter. Wood yellowish, close-grained, and durable; used for a variety of purposes—piles for bridges, wharves, and jetties; bed plates for machinery, millwrights' work, railway sleepers, &c. Bridges in various parts of the colony afford proof of its durability.

Besides the above, the following woods may be also mentioned :—

The *Kawaka* cypress, or cedar (*Libocedrus doniana*). A noble tree, attaining a height of sixty to 100 feet, and three to five feet diameter. The wood is reddish, fine-grained, and heavy, and said to be excellent for planks and spars. It is abundant in the forests near the Bay of Islands, and north of Auckland.

Rimu or red pine (*Dacrydium cupressinum).*—A tree with a trunk 80 to 130 feet high, and two to six feet diameter. Furnishes a useful red wood, clear grained, heavy and solid, largely used in the manufacture of furniture, the old wood being handsomely marked like rosewood, but of a lighter colour.

Monoao, or yellow pine (*Dacrydium colensoi*).—A tree from twenty to eighty feet high, wood light and yellow, greatly valued for furniture. It is one of the most durable and strongest timbers in New Zealand, posts of the wood having been in use among the Maories for several hundred years.

Tanekaha (Phyllocledus trichomanoides).—A slender handsome tree, sixty feet high, but the trunk rarely exceeds three feet in diameter. Wood pale, close-grained, and excellent for planks and spars; resists decay in moist positions in a remarkable manner.

Rata or ironwood *(Metrosideros lucida).*—Attains a height of thirty to sixty feet, with a diameter of two to ten feet. The timber of this tree forms a valuable cabinet wood; it is of a dark red colour and splits freely. It has been much used for knees and timbers in shipbuilding, and would probably answer well for cogs and spur wheels.

Pohutukawa (Metrosideros tomentosa).—A tree with numerous massive arms; height from thirty to sixty feet, trunk two to four feet in diameter. The timber is specially adapted for the purposes of the shipbuilder, and has usually formed the framework of the numerous vessels built in the northern provinces, as the tree is almost confined to Auckland.

VALUE OF THE EXPORTS OF TIMBER FROM NEW ZEALAND.

	£		£
1853	92,984	1872	26,718
1854	46,090	1873	44,039
1855	9,392	1874	44,450
1856	23,008	1875	40,046
1864	24,766	1876	49,847
1865	12,725	1877	50,901
1866	24,304	1878	39,074
1867	16,105	1879	35,735
1868	15,653	1880	51,225
1869	22,338	1881	71,328
1870	18,509	1882	114,700
1871	21,079	1883	151,608

(and wood ware £4,622).

The bulk of the shipment is kauri pine, and the greater part of the exports are made to Australia and the South Sea Islands, The number of saw mills in the colony is 230.

FURNITURE WOODS. — Having touched fully upon the heavy timbers and building woods, it may be well now to allude briefly to the fancy and furniture woods imported. After mahogany, the principal of these are walnut, boxwood, cedar, ebony, rosewood, maple, and satin wood. There are some others of minor importance, such as zebra wood, ziricote, snake or letter wood, partridge, and tulip.

Our imports of furniture and hardwoods, in detail, can be given but for a few years up to 1870; after that, the only wood enumerated in the Board of Trade returns, is mahogany.

Years.	Boxwood.	Cedar.	Ebony.	Rosewood.	Maple, Satin,&c.
	tons.	tons.	tons.	tons.	tons.
1855	1,322	2,081	808	1,465	450
1860	4,541	3,726	1,669	1,866	826
1861	2,964	2,968	1,495	2,441	837
1862	3,364	3,330	1,982	3,965	683
1863	3,962	2,464	980	2,126	530
1864	6,088	2,201	1,318	1,279	590
1865	6,109	3,803	1,279	1,468	570
1866	4,166	5,647	1,922	780	4,233
1867	2,730	4,665	1,176	558	6,402
1868	3,100	2,194	893	593	4,658
1869	5,534	1,107	628	912	4,915
1870	4,214	1,689	717	1,306	4,852

The following table shows our imports for a series of years of mahogany and unenumerated fancy woods :—

Years.	Mahogany, tons.	Unenumerated woods. tons.
1855	37,954	..
1860	47,710	..
1861	53,108	..
1862	53,798	13,870
1863	47,998	14,484
1864	41,008	15,429
1865	51,376	17,069
1866	53,548	15,659
1867	52,737	12,517
1868	41,925	61,808
1869	47,252	63,820
1870	32,732	66,181
1871	29,335	24,421
1872	33,920	37,088
1873	53,330	33,433
1874	64,674	32,360
1875	80,705	36,860
1876	52,461	43,292
1877	53,600	37,120
1878	44,227	25,177
1879	45,154	32,425
1880	41,349	37,846
1881	42,412	51,566
1882	36,478	52,770
1883	50,158	62,786

Our imports from Central America and Mexico have been as follows:—

Year.	From Central America.		From Mexico.	
	Mahogany.	Other woods.	Mahogany.	Other woods.
	tons.	tons.	tons.	tons.
1863	930	..	14,137	..
1864	2,340	..	6,685	..
1865	3,865	..	21,446	..
1866	3,778	..	18,406	..
1867	4,441	192	21,218	Only commenced to export in 1868 about 436 tons.
1868	5,705	1,159	20,479	
1869	6,537	1,423	24,038	
1870	6,871	1,482	15,585	658
1871	1,882	104	15,455	901
1872	4,757	1,405	15,090	2,634
1873	8,330	1,940	26,544	1,848
1874	6,665	2,357	33,542	2,278
1875	8,946	897	47,298	1,992
1876	5,519	637	33,243	990
1877	3,451	609	39,709	1,005
1878	3,203	526	28,278	1,974
1879	2,920	1,486	27,864	267
1880	3,295	1,107	24,096	723
1881	5,197	1,392	22,291	956
1882	2,799	1,018	19,444	1,009
1883	2,675	1,536	26,033	1,449

From British Honduras we have received the following quantity of mahogany in the last sixteen years.

Year.	Tons	Year.	Tons.
1863	21,921	1874	14,069
1864	20,927	1875	11,082
1865	14,775	1876	7,049
1866	16,063	1877	6,495
1867	12,604	1878	8,862
1868	7,979	1879	10,168
1869	11,177	1880	6,132
1870	2,542	1881	7,630
1871	5,309	1882	10,713
1872	7,705	1883	16,451
1873	10,801		

100,000 to 200,000 cubic feet of cedar are also exported.

The landings of mahogany in the Port of London in the last five years have been as follows, according to the annual circulars of Messrs. Churchill and Sim, in logs.

Years.	Honduras	Mexican.	Cuba.	St. Domingo	Total logs.
1879	10,973	13,247	2,191	1,995	28,406
1880	9,014	10 844	12,046	2,901	34,805
1881	7,931	11,556	9,187	1,004	29,678
1882	11,648	12,728	4.717	342	29,435
1883	17,851	14,407	4,534	1,475	38,267

The average consumption of mahogany in the United Kingdom would seem to be about 50,000 tons, and the supply appears to be very even, seldom ranging more than about 5,000 tons above or below this quantity.

Veneers are also imported from abroad, but there are no recent returns of the quantity named obtainable. The imports were in

	Cwts.		Cwts.
1860	3,504	1864	4,886
1861	3,186	1865	4,967
1862	3,772	1870	4,063

After 1870, veneers were, by the Board of Trade, summarised with the furniture woods. The timber used for veneering in the United States is principally curled and bird's-eye maple, beech, birch, cherry, ash and oak. These all grow in the States, and the beautifully marked and grained timber of the American forests finds fitting places in the onamental uses these veneers are put to.

The finest and most costly of the veneering woods is what is known as French walnut, but which does not come from France at all, but from Asia Minor and Persia. The tree is crooked and dwarfed, and is solely valuable

for the burr that can be obtained from it. In these large tough excrescences the grain is twisted into the most singular and complicated figures, and the symmetry and intricacy of these is one of the elements determining the value of a burr.

Formerly walnut burrs were in good demand, and fetched high prices, some rare ones, as much as £100 to £200; indeed, one shown at the Paris International Exhibition in 1878, sold for £1,000, or about 8s. a pound weight. But now there is very much less demand for burr veneers in the cabinet trade, the consumption being limited to pianoforte makers.

There are occasionally met with burrs in rosewood and mahogany, but these are of little or no value.

Of *Satin wood* the imports into Liverpool chiefly from St. Domingo, were in

	Tons.
1877	469
1878	165
1879	27
1880	231
1881	1,768
1882	3,320
1883	2,667

The following figures show our supplies of *Walnut wood* for a short series of years:—

IMPORTS IN THE UNITED KINGDOM.

Years.	Tons.
1855	538
1860	4,580
1861	2,913
1862	3,210
1863	5,932
1864	5,861
1865	5,689
1866	5,066
1867	3,388
1868	5,959
1869	6,536
1870	6,315

The imports into London alone have been in later years:—

Years.	American black logs.	Italian planks
1877	3,610	60,988
1878	1,552	38,054
1879	4,496	51,216
1880	3,892	30,695
1881	4,847	52,736
1882	4,940	37,255
1883	7,089	29,026

The imports into Liverpool have been as follows:—

	American.	Italian and Circassian.	Circassian
	c. feet.	logs.	burrs.
1877	29,973	2,422	..
1878	28,716	1,532	..
1879	44,510	1,205	..
1880	72,604	2,681	1,793
1881	109,366	1,935	311
1882	97,660	1,170	419
1883	148,693	1,163	92

Burrs which used to fetch £10 to £45 are now only worth £9 to £30.

Boxwood is chiefly used by the turner and the wood-engraver, and is getting very scarce, so that continual efforts are being made to find some good wood as a substitute. The imports of cedar are not large, and those of maple and satinwood even less. The latter is received from the East and West Indies. *Rosewood* is a term as generally applied as boxwood, and to as great a variety of trees in different countries; sometimes from the colour, and sometimes from the smell, of the wood. The cabinet rosewood imported from Brazil is the produce of *Jacaranda Brasiliensis* and some other species. The supplies that come to hand—some 3,000 planks annually into Liverpool—seem amply sufficient for the demand. The present quotations are, for

	Small Planks.	Large Planks.
Rio ..	£9 to £12 ..	£16 to £20 per ton.
Bahia ..	£8 to £10 ..	£15 to £20 „

The quantity of *Cedar* logs imported at Liverpool from Havana, Surinam, Mexico, and Honduras, have been:—

Average of the 5 years ending		Logs.
January,	1877	2,794
Year.	1878	1,100
„	1879	1,966
„	1880	3,882
„	1881	2,371
„	1882	3,320
„	1883	2,489
„	1884	4,370

Ebony.—Next to walnut, ebony is probably the most valuable of the cabinet woods. Occasionally a fine piece is found, that brings even a better price than French walnut. For a particularly fine piece £1 the pound has been paid, the main thing

being size, for it is difficult to get large pieces that can be used without cutting, Prime large logs from Ceylon fetch readily £14 per ton and upwards. Our annnal supplies of this wood are never large, 1,000 to 2,000 tons being the greatest imports.

The exports of ebony from Ceylon have been:—

Years.	cwts.	Years.	cwt.
1873........	46,635	1879........	24,399
1874........	29,176	1880........	42,616
1875........	15,750	1881........	..
1876........	9,007	1882........	13,392
1877........	20,796	1883........	17,547
1878........	21,919	(Value, £8,720).	

The ebony wood of commerce, so much used for inlaying, is the duramen of several species of *Diospyros*, a very large genus of trees, natives chiefly of Africa and Asia. From its hardness, durability, susceptibility of elegant polish, and colour (which has almost become another name for blackness), ebony has always been held in high estimation. Ebony was for a long time supposed to be obtained from *Diospyros Ebenaster* alone, but, in fact, several other species, scarcely differing from one another, yield this wood, in India, Siam, Ceylon, the Philippines, Madagascar, and Mauritius.

The commercial descriptions of ebony are generally ranged under three kinds, according to the countries from whence they are drawn—Mauritius, East Indian, and African. The Mauritius ebony is the finest grained, and the blackest, as well as the hardest and most beautiful, but it is the most costly and unsound. The East Indian is of inferior colour, and coarser grained; the African is the least wasteful, but the most porous.

We import from the West India islands about 2,000 tons of unenumerated woods annually, and a little mahogany. Many furniture woods of Jamaica, Demerara, New South Wales, and Vancouver's Island, present varieties of colour and of figure which are capable of producing most beautiful effects in workmanship. This was pointed out so far back as the London International Exhibition of 1862, when samples of the following woods, among others, were shown from Jamaica:—The mountain mahoe, of a green tinge; the candle wood, of a yellow; the mountain wichwood, nearly alied to the best satin wood; the white lance, and the green ebony. From Nova Scotia, the cedar, beech, white ash, rock elm, maple, &c.; and from Vancouver, the yellow cypress, maple, alder, and yew. These are sufficient to prove that the resources of the joiners and cabinet makers, in the matter of raw material at their disposal, are practically unlimited. All that is required is a little boldness and originality in seeking out and utilising new woods to replace the monotonous oak, mahogany, walnut, and rosewood of the cabinet makers.

Jamaica.—The cabinet woods of Jamaica stand prominent, and have taken prizes whenever exhibited at London, Paris, Philadelphia, &c. There is no doubt a good business could be done in exporting some of these beautiful woods, if the difficulty of procuring them from forests could be reduced. The want of labour and roads in the remote districts render the obtaining these woods too expensive at present to be resorted to as a business; but according to the Government surveyor there, the day will come when these districts will be sufficiently opened up to render the procuring of these woods profitable.

There are many close-grained woods in Jamaica, suitable for small articles, which would answer well, such as the bloodwood (*Laplacea hæmatoxylon*), of a deep red colour, and the fiddle wood (*Citharexylon surrectum*). The large price manufacturers are prepared to give for a hard wood with a close grain and not brittle, would warrant the procuring it at a great cost from the high mountains. Some of the Jamaica mahogany is very fine. Among the other island woods that may be mentioned are mahoe (*Paritium elatum*), which when fully ripe is of a blackish green colour, with darker or lighter bands; this makes a pretty contrast with lighter woods.

Yellow Sanders (*Bucida capitata*), is of a light yellow colour with satin graining, it takes a high polish, and is highly prized in cabinet works, where it sets off dark woods.

Braziletto (*Cæsalpinia brasiliensis*), being of a bright red colour, and taking a high polish, is also much used for ornamental cabinet work.

Yacca (*Podocarpus coricea*), is one of the most prized ornamental woods, and much used for furniture and cabinet work. The most flowery specimens grow on the elevated Blue Mountains, where it is crooked and magnificently cross-grained; the largest growth is about eighteen inches in diameter.

An approximate estimate gives about 800,000 acres as the timber producing forest of Jamaica, which, calculating only 400 ft. per acre, gives an annual production of 320,000,000

feet. About 3,500,000 feet is cut yearly for building purposes, and only about 40,000 feet is exported. Indeed, about 6,500,000 feet of lumber is imported annually from America. There is no doubt much of the best Jamaica timber must remain in the mountain fastnesses, on account of the difficulty of getting it out, until a railway is made to the foot of the hills.

It is scarcely necessary to speak of the timber of the other West Indian islands, but passing to the American continent, we find in British Guiana many excellent woods for shipbuilding and other purposes; 115 described kinds have been enumerated. The greenheart, the mora, and the souari, are all adapted for naval architecture.

Besides teak and oak, the following other kinds of shipbuilding woods were imported:—

1861	17,530	1866	4,932
1862	15,963	1867	4,039
1863	10,867	1868	9,919
1864	17,383	1869	4,987
1865	12,599	1870	2,491

(Since then they are not particularised in the Board of Trade returns.)

The appended return gives the exports of timber from British Guiana for the last 30 years, and these constitute about one-half of the total produce:—

	Cubic feet.		Cubic feet.
1851	177,780	1867	277,028
1852	127,356	1868	409,077
1853	144,031	1869	250,364
1854	206,962	1870	153,127
1855	173,914	1871	62,540
1856	297,354	1872	107,888
1857	330.772	1873	139,669
1858	257,508	1874	350,471
1859	276,378	1875	288,588
1860	493,922	1876	464,435
1861	825,230	1877	357,430
1862	652,112	1878	308,693
1863	407,839	1879	124,089
1864	816,812	1880	294,496
1865	503,849	1881	113,313
1866	249,614	1882	536,425

Besides 5,004,550 shingles.

As regards timber and furniture woods, the natural productions of Guiana vie with those of any part of the world. At Lloyd's greenheart and mora are classed amongst the few woods from different countries recognised as A 1 for shipbuilding purposes. Many others would, upon trial, be found equally useful.

In 1861 and 1864, over 800,000 cubic feet were shipped to the English market. The supply seems sufficient, and prices rule low, at £5 to £6 per load.

The average annual imports of greenheart and mora into Liverpool for the five years ending January, 1872, were 85,220 cubic feet. Since then they have been as follows:—

	Cubic feet.
1873	93,600
1877	296,285
1878	178,020
1879	59,177
1880	70,345
1881	60,584
1882	265,000
1883	109,000

The imports of hewn timber in loads from British Guiana in the last five years, have been as follows:—

		Furniture Woods.
1878	6,042	
1879	2,238	
1880	4,938	
1881	1,586	1,200 tons.
1882	5,123	5,168 ,,
1883	5,122	7 ,,

One other country only need be mentioned.

BRAZIL is very rich in woods, as the large and fine collections shown at the various International Exhibitions prove, but they have been very little drawn upon at present, although there is a bright future in store for them.

Within an area of half a square mile, Agassiz counted 117 different kinds of wood, many of them admirably fitted, by their hardness, tints, and beautiful grain, for the finest cabinet work. One of the most valuable, the tortoise-shell wood, a variety of zebra (? *Omphalobium lamberti*, Dec.) is found in large quantities on the tributaries of the upper Amazon. The jacaranda or rosewood we already import to the extent of 1000 tons yearly. The *pao santo* or holywood (*Kielmeyera* sp.?), the saboarana, both of which are rivals of the most beautiful walnut,—are wasted yearly on the Amazon, in amounts ample enough to veneer all the palaces of Europe. Still richer is the country in timber for the purposes of construction. Many furnish wood as durable as teak, and often of the most imposing proportions. Dining tables are to be seen, six feet in width, made wholly of one piece.

The following return shows our imports of furniture and hardwoods (chiefly rosewood, *Machœrum sp.)* from Brazil.

Year.	Tons.	Year.	Tons.
1864	1,087	1874	462
1865	1,024	1875	1,350
1866	203	1876	981
1867	311	1877	870
1868	337	1878	1,136
1869	639	1879	1,466
1870	704	1880	1,135
1871	1,146	1881	1,109
1872	1,512	1882	1,710
1873	2,472	1883	1,646

DYEWOODS. — Although the various dyewoods can scarcely be classed as timber, yet a brief glance at some of these will not be out of place before I close my paper, forming as they do important foreign forest products, and our imports reaching in value over half a million sterling.

Logwood forms the principal item, and has increased rapidly in quantity, for whilst in 1837, we retained but 15,000 tons for home use, in 1850 the quantity exceeded 30,000 tons; now the average annual imports are double that amount, as the statistics given below will show. Our supplies come from Campeachy, Honduras, St. Domingo and Jamaica.

The other dyewoods we import are red sanders wood (*Pterocarpus santalinus*), sappan wood (*Caesalpinia sappan*), both from India; fustic (*Maclura tinctoria*), from the Spanish Main and Cuba; Brazil wood (*Cæsalpinia brasiliensis*), and camwood and barwood (*Baphia nitida*), from West Africa. Nicaragua, or peach wood, is *Caesalpinia echinata*.

IMPORT OF DYEWOODS.

	Logwood. tons.	Unenumerated Woods. tons.
1862	41,257	15,538
1863	38,404	11,604
1864	41,625	13,027
1865	26,847	16,890
1866	35,960	11,328
1867	28,530	11,629
1868	35,468	26,402
1869	50,458	33,171
1870	62,187	26,720
1871	39,346	23,397
1872	46,039	27,286
1873	33,473	18,725
1874	43,471	16,023
1875	56,168	28,244
1876	64,215	24,855
1877	45,245	16,513
1878	38,311	16,037
1879	44,553	24,849
1880	69,250	27,260
1881	60,643	27,272
1882	41,262	26,252
1883	51,842	36,630

From the elaborate survey we have taken, it will be seen that the only sources from which we draw our present supplies of timber are the Northern States of Europe, and the Dominion of Canada. From the United States and our different Colonial possessions we can expect no supplies, or but very limited quantities; and it behoves, therefore, all timber producing countries to husband their resources, and by judicious forestry regulations to prepare increased supplies for the future demands of the world.

In conclusion, I may quote the remarks of Dr. Lyons, M.P., who has recently given much attention to this subject:—"Other nations are making the remark that, standing prominent as England does as the largest importer of timber, to no other country is the forest problem of such importance. What with timber and the other great forest products, her imports amount in value to £20,000,000 per annum, and it is not too much to say that not alone her maritime supremacy, but her position as a first-class Power in the world, depend on the forest supplies of these products, while her domestic industries would be hopelessly crippled if they were even temporarily suspended."

DISCUSSION.

Mr. SIMPSON said he had been much interested in the paper, being connected with the timber trade, and having had thirty-two years' experience in Western Australia. The jarrah wood of that colony was acknowledged, by those who knew its qualities, to be about the next thing to everlasting, and he hoped that in the next year a few cargoes would come to England. Almost everything in Western Australia was made of this timber, work-boxes, pianofortes, buildings, wharves, and jetties; it seemed to defy all known forms of decay, and was untouched by white ants and all other insects, so that ships built of it did not require to be coppered. It had been used above ground and below, in almost every situation in which timber could be placed, and was durable in all. On the table was a specimen from a tree cut thirty-two years ago, which had lain on the surface nearly all that time; it had been exposed to bush fires every two or three years, to the sun during the summer, to wind and rain during the wet season, and was as sound now as the day it was felled. Another piece he had cut from a small sapling used in a bridge at Bunbury, and so certified by the Government Resident, which had been 36 years in use, and this piece he had taken just between wind and water. There were about fifteen varieties of the timber and it could be obtained of any reasonable length up

to 60 or 80 ft., the trunk of the tree having no branches whatever. Another advantage was that it did not burn freely but only charred, which made it additionally valuable for building. It was poisonous to all insects, and when put into a white ants' nest they would not touch it. If a sheet of glass and a piece of this timber were put into such a nest, the ants would bore through the glass rather than touch the jarrah. The fresh sawdust put at the roots of a fruit tree would kill it, and it was stated by Baron von Müller to contain not only tannic acid but also sulphate of copper. Some of the wood was put into the Suez Canal seven years ago, and when examined lately, was found as perfect as the day it was laid.

Mr. CORNISH, having expressed his thanks to Mr. Simmonds for his paper, said he could corroborate all Mr. Simpson had said as to the value of the jarrah timber. He had seen it in use in many places, partly in the wharves at Melbourne, where it was put in to replace the white and red gums which had been eaten through in the course of five to seven years; and the reports of the harbour master, and others, stated that it remained absolutely untouched. Some of her Majesty's ships which had been repaired with it when in Australia, were found, on examination in England afterwards, to have remained practically uninjured. For large works, such as the Suez Canal, piers, harbours, &c., it would be very valuable. The matter had been laid before the directors of the Suez Canal, with the view that if the canal were widened, and piled with this wood it would be practically everlasting. Jarrah would be equally valuable for use in the Manchester or Panama Canals.

Mr. SMARTT said it was a pity that our English hedgerows, and many of our woods and forests, were filled with timber comparatively valueless. Nearly all the trees in Epping Forest were pollards, and were almost worthless as timber, the wood being only used for charcoal or firewood. He suggested that French walnut should be more largely planted, as it grew more rapidly than English—he had some which grew four feet in a year—though this depended a good deal on the soil. If more attention were paid to the matter, much timber would be grown at home which now had to be imported.

Mr. LIGGINS said if he understood that the jarrah was capable of resisting the action not only of insects and marine animals, but of preventing the formation of that vegetable slime, which so retarded a ship's progress, and made it necessary to coat vessels with copper, it was a most valuable discovery. With regard to furniture woods, as a West Indian planter, he had not only planted them, but had tried to sell them, and forty years ago he introduced several varieties to the English market, but he found that unless they were exceedingly beautiful for veneers, English cabinet-makers would not look at them, because they were so exceedingly expensive to work; cabinet-makers preferred rosewood, and still more, mahogany, which was much easier to work. He did not, therefore, anticipate much advantage from the introduction of these woods, except for very costly furniture, where expense was no object. The main point was the introduction of more generally useful woods. Having been in the backwoods of Canada, over the Alleghany mountains, and in the northern parts of South America, he did not hesitate to say that the weak point was the soft wood trade. Of hard woods, there was practically sufficient. He alluded principally to teak, which was the most valuable of all. Large ships were now always built of steel, but the decks were laid with teak, the deck being an important point in the strength of a large ship. The best ship he ever owned was built of Demerara greenheart, and the swearing he heard over her when she was being repaired and altered in a dry dock was something awful. It was almost impossible to get men to work at it more than half-a-day, in consequence of its extreme hardness. He believed she would last till doomsday, and Lloyd's surveyors said she was practically as good as the day she was built. Wood was not much used now for ship-building except for spars; and he was informed that if a gentleman in New York wanted to build a very fine yacht, he had to send to England for the Oregon spars for her masts, booms, gaffs, as the whole of this timber came to England. It was the finest wood in the world for this purpose. A friend of his had a yacht, the mainmast of which, when brought home, was 120 ft. long, though it had since been reduced 8 ft., and was one of the grandest specimens of wood he had ever seen. He must say, in conclusion, that in the West Indies he was more fond of planting trees than of cutting them down, and he wished all owners of land would adopt the same principle, and never cut down one tree without planting two.

Mr. SIMPSON said he should be happy to show Mr. Liggins a work by Baron von Müller, who visited West Australia specially to investigate the quality of the timber, and various other reports by engineers and shipbuilders. He might say that he had known ships built of jarrah which had sailed for 20 or 30 years without any copper, and he himself was working lighters which had been in use fully that time, which had never been coppered. This timber would not grow on good soil, only where there was ironstone, tons weight of which were sometimes lifted by the roots. The more ironstone there was in the soil, and the higher the elevation, the better the trees grew.

Mr. WM. BOTLY said that instead of a special school of forestry being established by the Government, the subject should be included in the curriculum at the agricultural colleges at Cirencester, and at Downton, near Salisbury, which, being in the neighbourhood of the New Forest, would offer great

facilities for the purpose. Forestry was now being taught at Cooper's Hill. It was satisfactory that so much attention was being paid to this question, as was shown by the Congress at Vienna in 1880, which was attended by representatives from all the principal countries.

Mr. PAGE asked Mr. Simpson if anything were known as to the action of jarrah wood on iron. As it had been proposed to sheath steel ships with it, it was important to know whether, seeing it contained so much tannic acid, it would act at all on iron nails.

Mr. SIMPSON said he would give not merely his own experience but that of various shipbuilders, collected by Mr. Manning, Government Engineer of Western Australia. It was one of the most remarkable facts connected with this timber, that if you put a bolt, no matter what size it might be, into it, when you took it out, a bolt of precisely the same size would go into the hole again. The effect of the iron, apparently, was to preserve the timber, and of the timber to preserve the iron. He could not say what the action was, exactly, not being a chemist, but a slight black skin was formed between the two, and the iron appeared to remain as perfect as when put in. He had seen on the Fish Rock, at Fremantle, the whole of the guy chains supporting the beacon there entirely perished, and the copper fittings likewise, but the pole itself was found quite perfect, when examined, though it had been standing 22 years. Mr. Story, of Sunderland, and other shipbuilders, said jarrah was far superior to teak; it was less liable to split, and it would bend freely, and without being steamed.

Mr. M. S. S. DIPNALL said the discussion seemed to have been devoted very much to one particular tree, and somewhat missed the large political and social point of view to which the reader of the paper had drawn attention. He had alluded to our having cut down and used our native timber much faster than it was produced; but he must point out that those who incurred the expense of planting very seldom reaped the benefit, though their successors might. Their friends in Australia began with the enormous heritage which Providence had conferred upon them, and might go on cutting as the Canadians had for a long period before they discovered they were getting short of timber, but it was not so in England. Many thousand acres of sandy and almost barren land were planted many years ago with fir, which came to maturity just at the time when they were wanted for railway sleepers, coalpit shores, and many other purposes. If anyone thought that planting could be undertaken as a good commercial speculation, he feared he would be mistaken; though if ever there was a time when such work could be undertaken profitably it was the present. The poor lands of Norfolk and Lincolnshire were now to be had very cheap, but the cost of planting would be about £10 per acre, and if the planters had to wait 50 or 60 years for a return, he did not think the speculation would be remunerative. He had known fir poles in Surrey, planted 60 or 70 years ago, fetch 4s. 3d. each; but in other cases, in Lincolnshire, he had known them only fetch 1s.; though owing to some large contracts being undertaken the price was soon raised. He fully recognised the importance of keeping up the supply of timber at home, but did not like to see false hopes entertained.

The CHAIRMAN said he was quite certain all present would join in a most cordial vote of thanks to Mr. Simmonds, for the very able and interesting paper he had prepared, the publication of which, in an enduring form, would be of the greatest value as furnishing a vast amount of information on a subject of the greatest importance. There were, perhaps, no two countries in the world so deeply interested in it as England and Canada, though for different reasons. Mr. Simmonds had pointed out that England was the greatest importer of timber of any country, and had also drawn attention to the fact that the forests of Canada presented about as grand a field for this industry as was to be found in any part of the world. They had no woods so enduring as that one to which so much attention had been attracted in the discussion; but in point of extent the resources of Canada were immense. From Nova Scotia on the Atlantic to British Columbia on the Pacific, nearly 4,000 miles apart, there were in every section of that wide dominion vast forests containing most valuable and important timber of various descriptions. Canada had no timber so enduring as jarrah or teak, but the chief engineer of the Canadian Pacific Railway told him, on returning from his visit to British Columbia, that he found an order being filled from China for six sticks, 120 ft. long, measuring 6 ft. square at the small end. In point of size, therefore, they could boast of as large timber as was to be found anywhere. They had also an enormous supply of that Oregon timber which had been declared to be so valuable that it was sent for to England from New York. The resources of Canada in this direction might be judged of from the fact that the census of 1881 showed that the industries of which wood formed the staple amounted to something like twenty millions sterling per annum, and the exports of timber from Canada in 1883 amounted to five millions sterling. He was glad to find that the somewhat sweeping censure as to the wasteful way in which these forests were dealt with was somewhat modified subsequently. The waste arose from the fact that in the United States and in Canada the forests were so immense, that the early settler going into those forests with his axe on his shoulder to clear the farm, came to look on a tree as an enemy, something to be got rid of in the most rapid manner possible. But as the country became more settled, different opinions were formed, and it was now acknowledged that the greatest injury which could be inflicted on a

country was to denude it of trees, the result being detrimental both to the climate and to vegetation, and consequently attention was now being given to replanting districts which had been thus denuded. Care was now taken in the management of the forests; only trees of a certain size were allowed to be cut, and it was found that by avoiding the destruction of the smaller trees, allowing the light and air to penetrate, the growth became so rapid, that after a few years an additional number of trees were of sufficient size for the axe. The various provinces were now enacting laws for the preservation of the forests, and the too rapid destruction was being stopped. It was interesting, looking at the matter not from an English or Canadian, but from an imperial standpoint, to know that, however great might be the demands of England for wood in all its various forms, she could turn to one portion or another of her own territories for all the supplies she needed. She occupied a position, in this respect, superior to that of any other country in the world, and with this additional advantage, that in drawing supplies to the centre of the empire from her remote colonial dependencies, she was creating that interchange of commodities, stimulating and fostering that interchange of commercial relations, which bound countries together by the strongest and most enduring tie, that of self-interest. With regard to Mr. Simmonds' estimate of the consumption of timber for railway sleepers, he believed it was under the mark, for having held the position of Minister of Railways for many years in Canada, it was within his own knowledge that the Canadian Pacific line consumed 2,700 to the mile, instead of 1,760. He concluded by formally proposing a vote of thanks to Mr. Simmonds.

The vote of thanks was carried unanimously, and the meeting adjourned.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The Board of Trade have granted an additional certificate with a view to ensure the protection of inventions exhibited next year, during the period from the 1st of March down to the 1st of May, the time during which the exhibits will be received and arranged. A previous certificate, dated August last, enabled exhibitors to secure protection for their inventions as from the 1st of May, the date of the opening of the Exhibition. Exhibitors desiring to avail themselves of this method of protecting his invention will have to comply with certain conditions stated in the Patents, Designs, and Trade Marks Act, 1883; that is to say, he must, before exhibiting, give the Comptroller of Patents notice of his intention to do so, and pay a fee of 10s. This notice must be accompanied by a brief description of the invention. After these conditions have been complied with, the exhibition of the invention does not prejudice the right of the inventor to obtain a patent for it, provided the application for the patent be made before or within six months from the date of the opening of the Exhibition.

A printed copy of the extracts from the Patents, Designs, and Trade Marks Act, 1883, bearing on this subject, may be obtained on application to the secretary, International Inventions Exhibition.

THE PHYLLOXERA AT THE TURIN EXHIBITION.

By P. Le Neve Foster.

It was a happy idea on the part of the organisers of the Turin Exhibition, during the International Congress on the Phylloxera, lately held in that city, to gather together in a small building situated near the marine department, a collection relating not only to the natural history of this insect, which has caused such ruin in the wine-growing districts of France and other countries, but also the various plans that have been adopted for the destruction of this pest.

The *Phylloxera vastatrix* first made its appearance in Europe, in 1863, at Pujault, in the department of Gard, and M. Planchon, of Montpellier, appears to have been the first naturalist to study the habits of this parasite. It was not, however, until the 18th August, 1879, that the phylloxera visited Italy, at Valmadrera (province of Como), and in the following March was discovered at Riesi, in Sicily, whilst in the autumn of the same year it made its appearance at Porto Maurizio, and at Messina. Like most insects, the phylloxera undergoes numerous modifications or metamorphoses during its existence, which may be said to be of two distinct characters, viz.—that in the air, and that below ground. The principal phases in the life of this insect are—1st, that of larva; 2nd, as an apterous female egg layer; 3rd, as a nymph; 4th, as a winged female; 5th, as sexual individual. In the first, it is microscopic, and of a yellow colour; in the next, of larger size, and exceedingly prolific, and of a darker colour. The female insect, which is larger than the male, during the months of August or September, deposits on the leaves two or three eggs, and the little insects, as soon as they are hatched, puncture the leaves, and so cause excrescences or galls to be formed, in which the insects develop, and soon commence laying eggs, these eggs, in due time, give birth to young, which soon become egg-laying mothers, and, like the first, remain wingless; some of these travel down from the branches to the roots, where they obtain their nourishment at the expense of the vine. Five or six generations of these egg-producing mothers follow

each other in succession, when some of the individuals begin to acquire wings, and commence to issue from the ground, and rise in the air, until the autumn, and spread to new vineyards, where they lay two or three eggs, and then perish. These eggs, in the course of a fortnight, produce sexual individuals, which appear to exist for no other purpose than that of reproduction, are without means of flight or of taking food. The female lays one egg, called a winter egg, which usually passes the winter unhatched, and is deposited in crevices, or under the loose bark of the old wood, the young of which either go directly to the roots and form root-feeding colonies, or gall-inhabiting colonies on the leaves. The last occur only in the form of apterous females, and are not essential to the propagation of species, and do, as compared with the root-inhabiting type, but little damage.

When first attacked, the vine shows no signs of infection, as the insect is only visible by aid of a lens, and the vegetation does not suffer for the first year. If, however, the roots are carefully examined, small excrescences of a whitish colour will be observed, and these are caused by the puncture of the insect, and it is in these that the root-dwelling type lives, multiplies, and hybernates, and it is in consequence of these wounds that the roots become no longer capable of furnishing nourishment to the vine. During the second year, the plant begins to show signs of decline, the vegetation languishes, the shoots cease to grow, the leaves become pale in colour, and the scanty bunches of grapes rarely come to maturity, and, finally, the insect having exhausted the plant, abandons its lodgings for a more suitable one among the neighbouring healthy vines, and the injured plant, the roots of which are no longer capable of performing their natural functions, usually dies during the third year.

Amongst the many plans which have been suggested and tried, in order to get rid of this pest, but none have as yet really given satisfactory results, and this is easily explained from the fact that any agent employed for the destruction of the phylloxera must penetrate at least one metre deep into the ground in order to reach it, and whilst capable of killing the insect must, at the same time, do no injury to the vine. Carbolic acid, petroleum, sulphide of lime, flowers of sulphur, subacetate of copper, tobacco juice, carbonic acid, chloride of lime, and a variety of other insect destroyers have been tried in due turn. Some viticulturists recommend the planting of garlic or hemp between the rows of vines, whilst the Academy of Sciences of Paris, in 1874, advised the spreading of sulphide of ammonia over the infected vineyards. The flooding of the vineyards, in order to drown out the insect, has also been recommended, and where it has been possible to apply such a remedy it has been entirely successful; but as vineyards are usually situated on hilly ground, it will be readily understood that this remedy is inapplicable in the majority of cases.

Another remedy that has been adopted, and which on account of the cost is clearly impracticable, is the substitution of sand for the earth in which the vines are grown, it having been found that the plants growing in a sandy soil are, to a certain extent, not attacked by the phylloxera.

The principal remedy, however, is the application of bisulphide of carbon, by injecting it into the ground, usually in a liquid state, by means of special implements that have been devised for the purpose, but great care must be taken to regulate the quantity in order to effect the object, and without injuring the vines. In any case this method is very costly, besides it being necessary afterwards to manure the plants before they completely recover from the effects of the attack.

In many cases the wisest course to pursue is to destroy the vineyard entirely, to cultivate the land with care, and then to replant it with vines capable of resisting the attack of the phylloxera.

The cultivation of the American vine, many varieties of which are proof against the assaults of this pest has found a large number of partisans, it having in many cases given highly satisfactory results, some varieties, such as the Jacquez, Herbemont, Cornucopia, Othello, and Canada, being grown for the direct production of grapes, whilst others, comprising the different varieties of the Vitis Riparia and Vitis Rupestris, viz., York's Madeira, Solonis, Vialla, Jacquez, Oporto, and Taylor, are planted, and serve as stocks to be afterwards grafted with the different kind of grapes suitable for the particular district and for the special description of wine it is desired to produce.

The Italian Government have done all in their power to encourage the cultivation of the American vine, and for this purpose obtained from America a quantity of seed, of which 6,760 lbs. was distributed, since 1879, amongst the various local agricultural societies and private vine growers.

The Minister of Agriculture has assigned five gold medals, ten silver, and twenty bronze to exhibitors in this section, and the Direction of Agriculture exhibits an important collection of maps, showing the districts invested with the phylloxera, drawings, photographs, and a quantity of reports and other pamphlets relating to this insect, and besides this, samples of the various tools and implements used for destroying the infected vineyards, as well as those employed for the injection of the bisulphide of carbon.

The Minister of Agriculture also shows an important monograph with diagrams illustrating the various processes adopted of the manufacture of the bisulphide of carbon by the methods of Peroncelli, Giraud and Aubert, Gally, Cazalet, and Deiss. The first manufactory of this substance in Italy was at Oneglia and Pisa, and at the beginning of the present year there were four manufactories in Tuscan, six in the southern provinces, three in Sicily, and one at Milan, making in all fourteen establishments, con-

taining seventy retorts, of which sixty are in use for about eight months during the year. The process principally adopted is that of Deiss; the quantity of sulphur required for each furnace of four retorts is from six to eight quintals (12 cwt. to 16 cwt.) per day, and which in 240 working days produce from 1,800 tons to 2,000 tons of bisulphide of carbon, a large quantity of which is being used in other industries, and some is exported to Tunis.

The Italian Government have purchased, since 1880, all the bisulphide of carbon required for the treatment of the vineyards in the localities ravaged by the phylloxera, from Italian manufacturers, the quantities and value being as follows:—

	Quintals.	Lire.
1879	26·78	1,279·0
1880	1,314·24	58,878·05
1881	1,461·75	56,205·87
1882	1,986·48	72,996·26
1883	5,886·35	200,818·05
1884	1,085·20	37,528·20
Total..	11,760·80	Lire.. 427,701·43

The Minister of Agriculture of France (Ecole Nationale d'Agriculture of Montpellier) have sent a quantity of photographs, maps, reports, books, &c., respecting the phylloxera, besides models, diagrams, preparations, roots, and dried specimens of vines illustrative of the damage done by this insect; a variety of drawings, photographs, and examples of grafting in various stages; a large quantity of tools and implements used for grafting, amongst the best of which may be mentioned those of Trabua, Petit, Saint-Cristole, and Guisquet; a collection illustrating the resisting qualities of the American vine, commencing with the seed, microscopic and other preparations of the roots; samples of wine produced from American grapes; drawings, photographs, and implements illustrating the various systems adopted for the destruction of the phylloxera, viz., by the bisulphide of carbon method, the sulpho-carbonate of potassa method, sulpho-carbonate of lime method, as well as those of other insect destroying substances; the treatment of vineyards by flooding, and that by the use of sand, with specimens and analysis of sands, in which the vines resist the attack of the insect, and specimens with analysis of those in which it does not.

The Minister of Public Works, Portugal, contributes a collection of reports and regulations respecting the spread of this pest in that country.

The Swiss Government also send a collection of reports, regulations, and other books relating to the phylloxera, together with maps of the infested localities, instruments and tools used for the inspection of vinyards, &c.

The School of Viticulture, of Alba, shows a variety of tools and implements for grafting and pruning vines, as well as those used for the application of sulphur, a variety of maps, pamphlets, herbariums, diagrams illustrating the various diseases to which the vine is subject, herbariums of American vines, models and miscroscopic preparations for the study of the phylloxera.

The schools of viticulture and winemaking of Avelleno, Cornegliano, Grumello del Monte, and numerous other institutions, exhibibit important collections, &c., illustrative of the various diseases which affect the vine, and the numerous parasites which infest it, as well as tools, implements, &c., of every description.

One of the most interesting entomological collections is that of M. F. Richter, of Montpellier, who exhibits twelve slides for the microscope to illustrate the different metamorphosis of the *Phylloxera vastatrix* (Planchon); six slides of the *Phylloxera quercus* (Boyer); *Phylloxera cœcinea* (Heyden); *Phylloxera corticalis* (Kaltenbach); *Phylloxera punctata* (Lichtenstein); *Phylloxera acanthochermes* (Kollar); *Aploneura Lentisci* (Passerini); and of the *Phylloxera salicis* (Lichtenstein). Besides various preparations in spirits of wine of the galls on the leaves and excrescences in the roots.

Samples of grafting shown by other exhibitors; amongst them may be mentioned M. Blanc of St. Gilles (Gard), who shows samples of fifteen different ways of grafting.

Most numerous are the systems proposed for grafting, amongst which the whip graft (*griffe anglaise*) which is recommended as one of the best by the congress lately held in Turin; the Champin graft also is advocated by numerous viticulturists; whilst grafting by "approach" may be found advantageous in many cases.

The American vine has become of greater, and o more comprehensive importance, on account of its now well established phylloxera resisting qualities, and it is now grown largely, both in Italy and France, as a grafting stock for European kinds, as well as being largely planted for direct production. The Count di Roasenda exhibits wine made in 1883, from the Solonis, Concordia, York's Madeira, and Elsimburg varieties of the American grape. Dr. Garroni, of Varese, wine made in 1882 and 1883, from the York's Madeira grapes. Signor Borghi, of Varese, also sends samples of wine made from York's Madeira, Clinton, and Vialla.

An important exhibit is that of Dr. Rizzetti, who, besides a collection of 75 varieties of the American vine cultivated in the grounds, shows a collection in pots of 50 seedlings of the *vitis rubris*, and 50 seedlings of the *vitis riparia silvestris*, sown last May; also 27 plants of Italian varieties grafted on American stocks. A herbarium containing 80 specimens of American vines, with a descriptive catalogue which cannot fail to be of great interest to the viticulturist. In addition to these are exhibited 80 different varieties of seed of American grapes, and a number of slides prepared for the microscope, illustrating the power of resistance of the American

against the attack of the phylloxera, as compared with that of the European sorts.

Dr. Rizzetti has established on the hills at Mongreno, a few miles distant from Turin, a nursery for raising this quality of vine, and has, at the present time, upwards of 100,000 seedlings belonging to thirteen different species, viz., the Riparia, Æstivalis, Labrusca, California, Candicans, Rutundifolia, Cinerea, Cordifolia, Rupestris, Arizonica, Lincocumini, Monticola, and Rubia, which last has only recently been introduced into Europe, and is highly esteemed on account of its resisting qualities. These thirteen species are subdivided into seventy-eight varieties, of which twenty-five varieties belong to the Æstivalis species, amongst which may be mentioned the Jacques, Herbemont, Norton's Virginia, and York's Madeira, which last are specially adapted for the direct production of grapes, whilst the twenty-two varieties of the Riparia are suitable as grafting stocks for European kinds, and the other thirty-one varieties belong to the remaining eleven species, which are all, more or less, suitable for planting in different localities.

Notwithstanding the advantages offered by this description of vine, on account of its phylloxera resisting qualities, it will be readily understood that viticulturists in general will be loth to replace the vines in full produce in their vineyards with young plants, the yield from which, for many years to come, must be insignificant.

Mr. F. Cassetta, of Alba, meets this difficulty in the following way:—By grafting on to existing Italian vines new roots of the American sorts, and that without disturbing in any way the economic conditions of the vineyard. To an existing vine he grafts on, as near the ground as it is possible, a scion of some American variety, which pushes rapidly with great vigour, and by the following spring this new shoot is sufficiently long to be bent down into the the ground as a layer, leaving the extremity above the surface, this layer naturally soon takes root, and should the dreaded phylloxera make its appearance, it is only necessary to sever the vine from its old roots, and in this manner it continues to grow with great vigour on the young and healthy ones that have been prepared for it. The advantages offered by this system over that of the replanting of the vineyards with young American plants, to be afterwards grafted with European sorts, cannot fail to be obvious to all viticulturists, for in the latter case, many years must elapse before the new vines can be in full bearing, whilst in the former the wine harvest is not lost for a single year.

Signor Cassetta shows an Italian vine of the variety known as *Barbera*, with a graft of York's Madeira, made last May, to be layered next spring. Also a vine of the same quality, grafted with York's Madeira in the spring of 1882, which graft was propagated as a layer in the spring of 1883, and in the month of May of the present year was separated from its old roots. During all this period the vine did not cease to produce the usual quantity of grapes.

BRITISH COMMERCIAL GEOGRAPHICAL SOCIETY.

The objects of this Society, which has lately been formed, are thus stated:—

1st. To collect from all portions of the globe information of a geographical character which may have a bearing on commerce.

2nd. To establish a library of reference and a map-room easily accessible to men during business hours.

3rd. To form a museum of raw and manufactured products, so arranged as to give information as to where they are produced, manufactured, and sold, and in what quantities; also the manner in which the raw products are brought into the hands of the manufacturer.

4th. To discover, and aid in opening, new markets for British goods, and sources of supply of raw materials.

5th. To discuss and consider ancient and modern commercial routes.

6th. To obtain and disseminate information on commercial hygiene, &c.

7th. To consider and discuss engineering undertakings likely to affect national interests, or have influence on the course of trade.

8th. To collect and formulate information about ports in all parts of the world, and the condition of the various hydrographical surveys.

9th. To discuss, with regard to their influence on commerce, all treaties or other acts tending to the concession, acquisition, or settlement of new territories or the alteration of existing boundaries.

10th. To support, as far as possible and proper, all commercial geographical explorations.

11th. To publish, monthly or otherwise, a journal containing the proceedings of the society, and giving information on the above-mentioned subjects.

12th. To hold meetings for the discussion of the objects embraced by the society.

In the report of the meeting held at the Mansion-house on the 15th of July, Commander Cameron points out that such societies as the present are very prevalent on the Continent, one founded at Havre in the middle of this year numbering over 400 members within a few weeks of its inauguration. These societies supply their merchants and manufacturers with the latest and most trustworthy information as to raw products, and the commerce and trade of the world, enabling them to get what they require, and also to find markets for their goods. He also cited instances, which had come under his own personal observation, in which trade—even in the British Colonies—had been wrested from English merchants by strangers, educated by the commercial geographical societies of their various nations.

Since this meeting was held, the "Institut Commerciale de Géographie" has been established at Paris.

Correspondence.

THE SANITATION AND RECONSTRUCTION OF CENTRAL LONDON: HOW FAR POSSIBLE AS A SELF-REMUNERATIVE BUSINESS?

THE BUSINESS BASIS OF THE PROJECT.

Since I first called attention to this question, by the offer, through the Society of Arts, of certain prizes for competitive essays upon its chief points, and by the paper which I read to the Society, on 6th February last, published in the *Journal* of the 8th February, further insight and consideration have benefited my scheme, and I am glad of this opportunity to re-state it in its later aspects. The business basis, let me here repeat—that is, the basis on which it depends for eventual full recoupment of all first outlay—is that increase in site or real estate value, which economists have long recognised as the "unearned increment." It is a feature unfailing to all commercially progressive countries like ours, and more especially to their larger town aggregations. It has been more than elsewhere the striking feature of London, and of central London most of all. The chief prospect of a self-paying reconstruction, therefore, depends upon holding to the expropriations, instead of the usual course of at once re-selling them, and holding for such term of years as may secure such adequate value-increment as will recoup all costs of the first purchase and clearing. But, first, I propose to substitute, for the invidious term, "unearned increment," that of "natural increment." Its cause is plain and simple enough. Natural increment is due to the increase of population, commerce, and wealth, upon the same inextensible site area. The natural increment is quite a different thing from increase of site value due to outlay of capital, in buildings or other improvement, upon the site.

THE GREAT PARIS RECONSTRUCTION.

Turning to this, the great sanitation and reconstruction effort of our day, let us benefit by the experience it supplies. As the work was undertaken for political as well as more direct considerations, and with imperial disregard for the mere profit and loss account, the result was no doubt exceptionally unfavourable in the latter respect. With a total cost, as I understand, of eighty millions sterling, the recoupment was only up to twenty millions, leaving the remainder as municipal debt. The expropriations were complete, and the areas, after being cleared, were promptly resold with the above result. The increase of site value since in these areas has been enormous, but all of it has passed, by this mode of procedure, into private possession, without benefit to the Paris ratepayers. In this extreme or extravagant case, complete subsequent recoupment, even by any mode, was, perhaps, out of the question. But by holding to the sites for a term, say of thirty years, so as to secure the natural increment for the municipality, it might have saved, at least, a very large part of its loss. And, further, there must be the impression that, if private enterprise of adequate resource had undertaken the work, it might possibly have entirely cleared itself.

HOW ITS HEAVY DEFICIENCY MIGHT HAVE BEEN SAVED.

Let us consider the difference of procedure towards so desirable a result, by means, say of an adequate joint-stock company or trust, as the improving agency. The sites then are to be leased instead of sold. The graduated rentals, and the price of eventual purchase by the lessee, are to be calculated together, so as in each case to clear the whole account. The trust, strong in natural increment assurance, must not hesitate to give the lessee the option of voiding his lease at every stage, allowing him valuation for approved and authorised constructions, because it is in this way that the trust best secures its own terms. The trust may have to erect the buildings in some instances, and similarly dispose of site and buildings. In each case, the calculation should not be for merely the exact clearing of the account, but with still a margin over for general guarantee. Such, then, is our different principle of procedure, and we are to secure along with it such term of years for "natural increment" as may be deemed ample.

COMPARISON OF LONDON WITH PARIS FOR RE-CONSTRUCTION PURPOSES.

London, as a field for the like enterprise, differs from Paris in at least one important feature—namely, the intense concentration of its leading business agencies within a comparatively very small inner central area, and the enormous value of that area. Thus, such a trust as I speak of could hardly ever dream of buying up the immediate surroundings of the Royal Exchange. At a conference on my project at the Mansion House last summer, invited by the prompt courtesy of the ex-Lord Mayor, one of the speakers adduced the case of Lombard-street, which, for expropriation purposes, had been lately, he said, valued at one hundred millions! Exaggerated as such a value must surely be, even a small fraction of it may well scare our proposed trust from all such costly ground. Such sections, therefore, are probably to be dealt with, if at all, only by the Corporation, with co-operative help, perhaps from more or less of the wealthy occupants. The particular sections in question are already, indeed, in comparatively good condition, owing to the very general private reconstruction of late years, the chief want now, in all that inner central area, being thoroughfares adequate to the enormous and ever-increasing traffic. The "block at the Mansion-house," which has become, at last, in its way, the daily feature of the City, is about to be partially remedied by a small extension of the open area.

But our trust's proposed self-remunerative procedure can have no application here.

But, on the other hand, at hardly a bow-shot from these almost priceless inner sites, are to be found crowded areas still in the most wretched condition, such, for instance, as some of the Houndsditch vicinities. As this evil condition must keep these areas at a depreciated value, they are certainly the most promising field for our trust, and, as need hardly be added, they are also the most urgent. The chief disadvantage hitherto, in trying to improve such areas, has been the inadequate extent of the scheme. No doubt the minimum of cost is best secured in such cases by biding the opportunities of expired leases or other causes of property coming voluntarily into the market for sale. But any indefinitely protracted, partial, or patching reconstruction of this kind, besides falling entirely short of the needs of the case, has all the disadvantage to the improved parts of leaving them still bedded in, or more or less in contact with, the unimproved. The subsequent maximum of value of improved areas can be relied upon only by clearing the entire of the ill-conditioned section, and placing it in thorough connection at all points with areas already in good, or comparatively good, condition.

Site-holders Preferring to Co-operate Instead of being Expropriated.

Throughout the City, of late years, there has been quite an unprecedented scale of private reconstruction—an activity which, as regards both its extent and its style, seems in curious contrast with concurrent complaints of general trade depression. This is a decidedly encouraging feature for our proposed trust, the inference being that the pressing requirements of modern business do really make such work remunerative, even although, in this partial and scattered way, it is conducted at much disadvantage. A further inference is, that many, perhaps most, siteholders will co-operate with the trust, instead of submitting to complete expropriation. The trust must welcome this aid, because it will thereby reduce its budget, and be able to embrace a larger and more effective field than would be otherwise financially possible or prudent. It seems indeed only fair that, in schemes of reconstruction, siteholders be allowed, as far as is possible, to avoid compulsory expropriation by cooperating, at their own respective cost, with the proposed and authorised improvement. There has been, within the last year or two, a clearer and more general apprehension of the feature of "natural increment," so that this voluntary co-operation would probably be largely afforded, seeing that it reserves to the site-holder all the increment promise of the future.

Constitution of the Proposed Trust Agency.

This part of my scheme stands much as at first stated. The capital for so great and responsible a work should not be less than ten millions, but this demand may be met in the least exacting way, by calling up one tenth only, and leaving the rest as liability. The latter is, for guarantee purposes, practically as good as the money itself, if there be a stable and responsible proprietary; and the best way to secure such is by having the trust shares of exceptionally large amount. I would say, therefore, shares of as much as even £10,000, and I would aim still further to limit proprietors to one such share each, so as to have the Trust constituted of a comparatively permanent body, say of one thousand persons, all of whom might become interested in, and variously useful to, the work.

But with a capital of this form and amount, most of the required funds must be raised outside, that is, by loan issues, and the rate of interest which the trust will have to pay, will depend on the security it can offer. I propose here for the trust, as a reasonable concession under all circumstances, that these issues be secured by a contingent rating liability of the City. The risk seems here but nominal to the ratepayers, who have all the care of private interests besides the ten millions capital in the breach; but the boon to the trust will be real, and save it perhaps one per cent. in the rate of its interest payment. The trust's remuneration, or dividend on its capital, should, in this case, be a fair mutual agreement between it and the ratepayers' representatives. I have proposed six per cent. on capital paid up, and one per cent. on liability; which makes in all as much as fifteen per cent. if reckoned on the paid capital only, while it weights the enterprise with as little as one and a-half per cent. upon the necessary total capital of ten millions. If the work, as it proceeds successfully, will authorise still more dividend, the trust, if it ventures on any increase, should then in all fairness give up the rating security as to any further loan issues. The trust will not ask any assisting loan from Government. It will rely for complete recoupement upon this rating concession, together with an adequate time, say thirty years, for natural increment of site value. This term of years surmounts all subwaves of temporary commercial depression or stimulus, and gives, successively, solid and reliable value-increments.

Lastly, I propose to put the trust under complete control of Government and municipality, as we will thus, in so novel and responsible an enterprise, most easily secure adequate powers of action. No step is to be taken, therefore, without approval of either authority, the Government being the final arbitrator in any differences. The Board of Management will thus include representatives of both. The public interests being thus safeguarded, the trust will demand the fullest and promptest powers.

Some Leading Features of London Reconstruction.

Our trust must attend mainly to what will "pay." But some ambitious designs for central London improvement may not prove eventually unremunera-

tive, if they can be carried out. The chief obstacle is the difficulty of touching the costlier central areas, as already stated. I conclude by re-calling three specially desirable features of the sanitation and reconstruction of the London of the future. First, a roomy and continuous "subterranean," to accommodate all modern changes and progress in lighting, water supply, sewerage, and electric force applications, without, as hitherto, interminably breaking up our streets. This spacious and interconnected under area might be useful in relieving the overcrowded streets above of their slow and heavy traffic in central parts, which may be too costly for street-realignments. Second, a terrace structure, with bridged connections, so as to lift foot-passengers out of the dangers of the streets, besides ornamental effect, and the remuneration to be expected from the double line of business accommodations. Third, to devote the roofage generally of the re-constructed city, so as to realise Dr. Richardson's pleasant, and quite possible idea, of recreation-parks or gardens in those upper regions, rendered easily accessible by our modern lift system. If we may hope, as perhaps we already may, to prohibit smoke to the proposed new city, even the heart of London may enjoy some approach to the pure air of the country.

W. WESTGARTH.

SMOKE ABATEMENT.

Will you allow me to illustrate Mr. Fletcher's remarks on this subject by a short statement of fact?

The chimney of a corn mill near here, in which I am interested, had long been a standing nuisance, and became a few months ago the subject of a series of threatening letters from the Clerk to the Local Board. As I happened to know something of what Mr. Fletcher had accomplished in smoke prevention, we sent our engineer over to Warrington to see him and learn what he could. Circumstances prevented anything more than a very partial adoption of Mr. Fletcher's system, and what we did was done in a very rough and ready way; yet we have effectually disposed of the difficulty with the Local Board, and are saving 25 per cent. in fuel and labour in stoking. The whole cost involved was that of a few cart loads of firebricks and a week's work of a couple of bricklayers.

W. WILKINSON.

Eldon, Bishop Auckland,
December 15, 1884.

General Notes.

ANTWERP EXHIBITION, 1885.—Mr. Grattan has been appointed British Commissioner for the Fine Arts, as well as for the Industrial Exhibition.

THE PARIS EXHIBITION OF 1889.—Official sanction having now been given to the above Exhibition by a decree of the French Government, the matter assumes a practical shape, and the plan of action would seem to have been more or less fully matured. In a report made to the President of the Republic by M. Rouvier, the Minister of Commerce, the history of past Exhibitions is touched upon, and the choice of 1889 for the next international display is vindicated on the ground of being historically appropriate, while, at the same time, following out the principle of the interval which has on former occasions elapsed between similar events. The comparative experience gained in 1867 and 1878 has shown, it is remarked, that the time of preparation in the latter case (two years) was insufficient, and in reverting to the idea of four years preliminary work, it is hoped that the results achieved will be of an unexampled character. It is proposed to divide this interval into two periods of preparation and execution, the former being arranged on as methodical a system as possible, in order to facilitate the operations to be carried on during the latter time. The necessary steps will shortly be taken for appointing a preliminary commission. Amongst the various projects already spoken of, is one which would embrace in the Exhibition not only the Champ de Mars and the Trocadero, but also the esplanade of the Invalides and the Palais de l'Industrie.

BRITISH ASSOCIATION.—At the close of the British Association Meeting at Montreal, the suggestion was brought forward that, in commemoration of the meeting, and as a recognition of the hospitality with which the members of the Association had been treated in Canada, it would be a graceful act to form a fund for the purpose of founding a gold medal at the McGill University at Montreal. After consultation with the authorities of the University, it was agreed that, subject to further consideration, the medal should be given annually, in the Faculty of Applied Science, in which there is at present no prize of this sort. Lord Rayleigh, the President of the Association, undertook to act as treasurer, and Mr. W. Topley and Mr. H. Trueman Wood as honorary secretaries. In answer to an appeal circulated amongst the members in Canada, and to a circular which has been issued in this country since the return of the Association, a sum amounting at present to £540 has been subscribed. Deducting the necessary expenses of printing and postage, there will remain an amount of something over £500 to provide the medal. The General Committee of the Association have agreed to provide from the funds of the Association sufficient for the purchase of a die, so that the interest resulting annually from the investment of the whole of the above amount may be available for the medal itself. The honorary secretaries will be glad to receive contributions from any members of the Association who may not yet have subscribed. These may be sent to them at the Society of Arts' House, John-street, Adelphi; or may be paid in to the account of the fund, at Messrs. Hoare, 37, Fleet-street.

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FRIDAY, DECEMBER 26, 1884.

All communications for the Society should be addressed to Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

All the tickets for these lectures having now been disposed of, the issue is stopped. As all the available accommodation will be required for those members who have applied for tickets, it will be understood that no member can be admitted without a ticket.

Proceedings of the Society.

CANTOR LECTURES.

ON THE USE OF COAL GAS.

By Harold Dixon, M.A.

Lecture I.—Delivered Monday, Dec. 1, 1884.

Coal gas is a mixture of invisible gases which are produced by the destructive distillation of coal. To-night I do not intend to say anything about the processes employed in the manufacture of coal gas, or the methods used for its purification. I am going to speak to you about the physical properties of the gas as it is delivered to us from the gas mains, to consider what kind of a body this coal gas is, what are the products of its combustion, and the methods in which it may be burnt.

First of all we may take, as it is the most striking physical property, its inflammability. When a heated body is brought into coal gas escaping into air, it ignites and burns with a flame sometimes luminous, sometimes non-luminous, according as it is unmixed or mixed with air. In the case of gas escaping directly into air from a pipe we have a luminous flame; where the gas first mixes itself with air we get a non-luminous flame, and of these non-luminous flames there are several kinds, from an explosion on the one hand, when a very rapid inflammation of the mixture of the gas and air passes through the whole mass of it, to the gas and air burning quietly, on the other hand, as I have here in this Bunsen burner. Let me show you first of all a few experiments on the inflammability of coal gas. If we take an ordinary bit of wood and light it, and in a short time blow it out, so that we have a glowing red end, and bring it into escaping coal gas, we find that it does not light it; bring something hotter—a poker at a fairly bright red heat—and this also fails to ignite it. I will compare it with a jet of hydrogen; the difference between them is fairly well marked. The poker is visibly red hot, but it fails to ignite a jet of coal gas, whereas it ignites a jet of hydrogen gas. Coal gas is ignited only at a very bright red heat; a poker has, for instance, to be a bright red, visibly red in day-light, in order to ignite coal gas; hydrogen is ignited at a slightly lower temperature. Coal gas contains about half its volume of hydrogen, but, curiously enough, it is not ignited at the same temperature that hydrogen is ignited at. The other large constituent of coal gas, viz., marsh gas, ignites at a still higher temperature. Davy, who experimented first on the ignition points of gases, says that an iron bar must be at a white sparkling heat in order to ignite marsh gas. Now hydrogen, we have seen, ignites readily enough with a red-hot poker; coal gas is not ignited with a poker that is visibly red hot; it will, however, ignite when the poker is at a cherry red heat.

The constituent of coal gas next in bulk is carbonic oxide. That ignites almost at the same temperature as hydrogen; it is very difficult to detect the difference between the two igniting points. But there is one constituent of coal gas present in a very small quantity, viz., bi-sulphide of carbon, which ignites at a very low temperature.

If we take a little liquid bi-sulphide of carbon, and pour it into a glass vessel, so that it will mix with air, we find that this mixture of air and carbon bi-sulphide vapour is exceedingly inflammable. I will warm up this glass rod, and you see it ignites the vapour readily. The temperature of the ignition of carbon bi-

sulphide vapour and air is about 300° Fahr. Now it might be supposed that the presence of a minute trace of the vapour of carbon bi-sulphide would confer its inflammability on coal gas. If we mix a little of this vapour with hydrogen, or with carbonic oxide, we find that it does confer its inflammability on those gases; but if we mix it with another constituent of coal gas, viz., olefiant gas, we do not find the inflammability of carbon bi-sulphide given to the mixture. The presence of olefiant gas destroys the low igniting point of a mixture containing carbon bi-sulphide. This is curious, but I know no explanation of the fact. It was, I believe, originally discovered by Dr. Frankland, who experimented with these various mixtures, and found that a mixture of olefiant gas with carbon bi-sulphide ignited at no lower temperature than olefiant gas itself.

Now, marsh gas is the constituent of coal gas which ignites at the highest point; then comes olefiant gas, then hydrogen, then carbonic oxide, and then this carbonic bi-sulphide; but the coal gas itself ignites at about a mean temperature, that is to say, at a cherry red heat. Now I will show you another experiment on the ignition point of coal gas. We may cool gas down until we put it out. There is for every gaseous mixture a certain temperature at which it will burn, and below which it will go out, and if we place in the flame a mesh of iron or copper wire, so as to conduct the heat away from the gaseous molecules, we may cool the flame down below its ignition point. Let me take a large mesh and put it down over the flame; the flame passes through it; there are not enough pieces of wire to conduct the heat away, and bring it down below the ignition point. If we take a mesh a little smaller, and bring this down on the gas flame, we find the gas put out; the coal gas passes readily through the mesh, as we see by its igniting when the mesh is red hot. Taking a still smaller mesh, we find the flame is put out completely; that is to say, this mesh of iron wire conducts away the heat from the gas, and brings it down below its ignition point. On this principle safety lamps are constructed; and I will say just one word about them. Safety lamps have been made for use in coal mines, where the gas which is met with is marsh gas. I believe that no free hydrogen, and no free olefiant gas is found in coal mines; it is all marsh gas. Now, marsh gas has this exceedingly high ignition point, and, therefore, a safety lamp which is quite safe in a mine with a mixture of air and marsh gas, is not safe in a mixture of coal gas and air. To ensure safety in a mixture of coal gas and air, one must make the mesh of the lamp still smaller than is used in mines.

Now, the next property of the gas, one which follows from this, is the fact that it burns with a flame in air. This burning with a flame is entirely a relative phenomenon. The molecules of the coal gas, viz., the hydrogen, the carbonic oxide, and the hydro-carbons unite chemically with one of the constituents of the air, viz., oxygen, and in this chemical union the vibrations are produced which give us the sensation of light. Whenever we have two gases uniting chemically together at a high temperature, we have this phenomenon of flame, but on no other conditions. A solid body burning in a gas does not give a flame, only one gas uniting at a high temperature, or burning with another. Now, if we lived in an atmosphere of coal gas, it would follow that coal gas would not be a combustible substance, but the air would be, and oxygen in a still higher degree. Flame occurs at the bounding surface between two gases entering into chemical combination one with the other. I can show you an experiment where a flame of air may be seen burning in coal gas, as well as a flame of coal gas burning in air. In this little apparatus on the table there are two tubes entering through the cork at the lower end, one of them broader than the other; one to admit air, and the other coal gas. I will connect one of these tubes to the gas supply, so as to let coal gas enter into it, and fill the glass globe. We have now an atmosphere of coal gas there, but since there will be an upward current, it will draw some of the air into the globe through the other tube. This jet of air is now lighted, and on lowering the lights of the room you will be able to see, especially when the moisture which is first of all precipitated on the sides of this globe has disappeared, that the air is burning in the atmosphere of coal gas. To make it a little brighter, I will push up a platinum wire with a borax bead at the end, so as to colour the flame. That it is really air burning in coal gas I can make plain, by lighting the excess of coal gas which is now pouring out at the top of the globe. There you see coal gas at the top burning in air, and underneath the air burning in the coal gas. I have to stop the supply of air to put the flame out, otherwise there would be an explosive mixture formed, and an explosion inside.

Before I pass on to treat in more detail of

the chemical constituents of coal gas, I will try one or two more experiments on its physical properties. Let us consider now its specific gravity. An easy way to show that is to blow a soap bubble with it. With the pressure of coal gas we have here we can blow a bubble, and if I am skilful enough to detach it, you will see it rise, showing how much lighter it is than air. [On rising a short distance, the soap bubbles were ignited by a taper.]

Now, of the constituents of coal gas, hydrogen is by far the lightest; next to it comes marsh gas, after that carbonic oxide. The other constituents are comparatively heavy. One of the properties of a light gas is its power of passing rapidly through a porous substance, such as plaster of Paris, or compressed graphite. The explanation of this, on the dynamical theory of gases, is, as you know, that the gases are composed of a number of small molecules dashing about in straight lines, and coming into collision one with the other and with the sides of the containing vessel; and where there are minute interstices in the walls of the vessel the molecules pass through these interstices, and we find an exchange of the gases outside such a vessel with the gases inside. Now, consider first of all, for the sake of simplicity, the case of two gases well known, oxygen and hydrogen. If we had a porous vessel with hydrogen inside, and oxygen outside, we should find that the hydrogen penetrated through the interstices of the vessel four times as fast as the oxygen went the other way. On the dynamical theory of gas this is explained in the following way. Hydrogen gas is made up of a vast number of small molecules of hydrogen, and oxygen gas is made up of a vast number of small molecules of oxygen; and the hydrogen molecules are travelling four times as fast as the molecules of oxygen. So that, taking any given portion of the surface of the vessel, and considering what number of collisions there will be between the hydrogen and the oxygen molecules respectively and this surface, we see that if there are the same number of molecules in the two gases, and the hydrogen molecules are travelling four times as fast as the oxygen molecules, the hydrogen molecules will come into collision with this surface four times as often as the oxygen. Now, if there are a certain number of interstices in this surface through which the gases can pass, the quantity of hydrogen which will go through will be four times the quantity of the oxygen which will go through in the same time. That is the explanation of the phenomenon of diffusion on the dynamical theory of gases. Let me show you a few experiments in which this diffusive power o coal gas, and especially of the hydrogen and marsh gas contained in it, comes into play. The gases pass through the walls of a porous vessel, and decrease or increase the pressure within the vessel according as more gas comes from the inside to the outside, or from the outside to the inside. This vessel is made of one of those porous pots used in a Bunsen cell; I have closed it with a paraffin cork, through which I have passed a long glass tube. I dip this open end in a coloured liquid. Now, as it stands here in the air, this vessel is full of air, and it is surrounded with air outside, the two being of the same density; so that the same number of molecules of air are passing out from the inside of the vessel into the atmosphere of this room as are passing from the atmosphere of the room into the inside of the vessel. The pressure, therefore, inside remains constant, and if we put any coloured liquid into the tube it remains perfectly stationary. But if we plunge the vessel into a lighter gas, such as coal gas, on the theory we have been considering, this coal gas, or some of its constituents, will pass more readily through from the outside to the inside than the air which is now inside will come out, consequently there will be an increase of the quantity of the gas inside, the pressure will be raised, and we shall find bubbles of gas escaping from the end of the tube. I can put this into an atmosphere of coal gas by placing this glass jar over it, and by means of an indiarubber pipe letting some gas into it. Bubbles of gas are now pouring out from the end of the tube, and I stop the supply of gas. Now what will happen? There is a certain amount of coal gas gone in, and it has driven an equal volume of the air out. If I take the glass jar away, we now substitute the air for the coal gas outside, and you see the liquid rush up the tube, showing a diminution of pressure. If I put the glass vessel containing the coal gas back again over the porous vessel, the pressure is increased, and the liquid is driven down again. You see, corresponding with the nature of the atmosphere outside, you have the variation of pressure inside accurately marked by the rise and fall of a column of coloured liquid in the tube connected with the porous vessel.

Now, an instrument could easily be made—

I think a French engineer has made such an instrument—by which the pressure of coal gas would be detected in a room. I know such an instrument has been used in mines to detect the presence of marsh gas. If, instead of coloured water in this tube we had mercury, it would not run up so far, but it would run up several inches, and if we went into an atmosphere of marsh gas, with this porous vessel filled with air, the marsh gas would enter more quickly than the air would pass out. The pressure inside would increase, and, consequently, the mercury would be down. Now, it would be easy to cause the mercury to make metallic contact with a wire, and so connect a battery with a bell. Taking such an instrument as this into a mine, if there were a certain per-centage of marsh gas present, it would increase the pressure inside sufficiently to drive the mercury down until metallic contact was made, and then a bell would be rung. Exactly the same thing would do for coal gas. If one wanted to know whether coal gas was escaping anywhere one might have such an instrument as this connected with a tube of mercury, two electric wires, and a Leclanché cell, and the wires might be carried to an office at any distance, and connected with a bell. Then, whenever coal gas escaped into the atmosphere where this porous vessel was, the pressure would increase inside, electric communication would be made, the bell would be rung, and you might go and find out where the escape was. I merely suggest that as a method which would be easily applicable for discovering, at a distance, whether there was an escape of coal gas.

One effect of this rapid diffusion of the very light hydrogen and marsh gas in coal gas is this, that these light gases mix themselves rapidly with air, and form an explosive mixture with it. It is the presence of hydrogen in coal gas which makes it dangerous. Owing to its lightness, hydrogen siphons itself upwards through a bent tube. Here is a little apparatus to illustrate this siphoning of the hydrogen, and also the rapid diffusion of hydrogen with air, in order to form an explosive mixture. The same experiment may be made with coal gas, but it takes a longer time. The apparatus consists of a cylinder hanging by an upright, inverted and closed at the lower end by a piece of paper stretched round it by an india-rubber ring. Passing through a hole in the paper, there is a U tube with its shorter arm at the upper part of the cylinder. The longer arm is outside the cylinder; to it I can attach a tube from a hydrogen apparatus. By turning on the tap, I can pour hydrogen into the cylinder. Hydrogen, being lighter than air, will displace the air at the top of the cylinder, and drive it out at the bottom; but it will not only do that, it will also diffuse with the air. I will, first of all, pass hydrogen in until I judge the cylinder is pretty well filled, then I will take off the tube here, and allow the hydrogen in the cylinder to siphon itself up the longer arm of the U tube. Then as the hydrogen siphons itself up, some air will be drawn in at the bottom, and owing to its rapid diffusive property, the hydrogen will mix itself with the air, and we shall get an explosive mixture inside the vessel. The flame at the top here will begin to jerk, and perhaps to sing, and then it will run down and fire the explosive mixture. We must allow it a few minutes to fill before it would be safe to light. I now light the hydrogen at the end of the U tube. There is the hydrogen burning and syphoning itself up. Now it is beginning to sing, and the explosion follows.

I will now show an experiment on the power of platinum to light a mixture of coal gas and air, by allowing a slow combination to take place between the hydrogen and the oxygen of the air. Owing to this chemical combination the platinum increases in temperature until it reaches the ignition point of the gas. I warm up this little spiral of platinum, then take it out of the flame, and allow it to cool, and put it in an unlighted jet of gas; it becomes hot, glows, and finally lights the gas. That is one way in which I have attempted to determine the different ignition points of these gases. It is not a very accurate way, but still it gives some approximation towards the truth. The platinum has to attain a bright red heat before the coal gas ignites.

I will now go on to consider in more detail the various constituents of coal gas. I have written on the black board approximately the composition of ordinary coal gas. The hydrogen varies between 40 and 50 per cent., sometimes a little over 50 per cent., but in no analysis I have ever seen or made have I found over 51 per cent. We may take it roughly that the hydrogen is 50 per cent. of the coal gas. Marsh gas varies between 35 and 42 per cent. I have taken it at 40 per cent. Carbonic oxide varies from 6 to 8 per cent., and the most important of all, ethylene, and the other hydro-carbons

of the same chemical type as ethylene, which may be classed together as olefines, occupy $3\frac{1}{2}$ volumes of the 100. In the next column I have put the volume of oxygen required to burn each of these constituents of coal gas. The 50 per cent. of hydrogen requires 25 per cent. of oxygen. The marsh gas requires double its volume of oxygen; the carbonic oxide requires half its volume; the olefines require about six times their volume of oxygen to burn them. In the next column are arranged the volumes of steam produced by the burning of these various constituents; 50 per cent. of hydrogen requires 25 per cent. of oxygen to burn it to 50 per cent. of steam. In the last column is put the volume of carbonic acid produced by the burning of these various constituents. Hydrogen gives no carbonic acid, for it contains no carbon; marsh gas produces double its volume of steam, and its own volume of carbonic acid; carbonic oxide, no steam, and its own volume of carbonic acid, and the olefines form about 20 volumes of steam and 14 volumes of carbonic acid.

With the properties of hydrogen most of us are familiar. It burns readily in oxygen, and explodes if mixed with half its volume of oxygen. It burns in air with a non-luminous flame. I can attach to this Kipp's apparatus, a lamp in which the hydrogen may pass directly up to this steatite burner, and there we can light it. I have put into the body of the lamp some liquid olefines to show the influence of those hydro-carbons on the flame. You see the hydrogen gives barely any light at all, but by mixing it with a slight trace of the vapour of the hydro-carbons belonging to this olefiant series, we get immediately a brilliant flame.

I have prepared samples of these various constituents of coal gas. All of them are invisible. Here is hydrogen, carbonic oxide, marsh gas, and ethylene. I will show you as quickly as I can one or two experiments with these gases. First of all, the union of hydrogen and oxygen to form water. By means of this pneumatic trough I pass a little of the hydrogen into a glass explosion tube, so as to fill it roughly two-thirds full. Then mixing oxygen with it, I ignite it. You see the flame gives scarcely any light, but there is a loud report owing to the sudden production of a volume of steam at a very high temperature. I will not take up your time by showing the explosion of all these gases, but I will light one or two of them in the air. Here is some marsh gas. After the first moment the flame becomes blue and almost non-luminous. The other constituent of coal gas, viz., carbonic oxide, of which there is 6 to 8 per cent., burns with a characteristic blue flame, with the oxygen of the air to form its own volume of carbonic acid. This is a bottle containing ethylene. I will fill a small jar with the gas, so that the air can get at it rather better than it can in this bottle with the narrow neck. Under the water of the pneumatic trough one can easily transfer the gas from one bottle to the other. This ethylene has an exceedingly luminous flame when one burns it in this way in the air, but it always smokes, and an illuminating gas, made with a very large per-centage of ethylene, would smoke unless it were burnt with certain precautions.

If we ignite a mixture of coal gas and air, we find that if the mixture is made in the right proportion, we get an explosion. If the mixture is made in other proportions, with either more or less air than a certain quantity, it will not explode. The limits of explosion are from $3\frac{1}{2}$ to $9\frac{1}{2}$ volumes of air for every volume of coal gas. Of course coal gas differs a little in its qualities, and so the limits cannot be exactly defined, but those are about the limits. If you mix four volumes of air with one of coal gas, a flame will be propagated through it, and if you mix nine volumes of air with one of coal gas a flame will be propagated through it. I will try one or two experiments of this nature, mixing a certain volume of air with a certain volume of coal gas. First, I will take the lesser quantity of air. I have filled this glass cylinder with air, about two-thirds full, and I will now fill it up with coal gas. We shall find we are just on the limit of an explosion. We may be just on one side or the other, I cannot tell. I plunge a lighted taper in suddenly; the mixture burnt, but there was no explosion down the tube, it simply burnt where the air got access to it, so that three volumes of air to one of this gas is not explosive. I will now go to the other extreme, and take nine or ten volumes of air to one of coal gas; this is just within the limit, there is a slight explosion, but hardly any noise. I will now repeat the experiment, taking one volume of coal gas to five or six of air. Here we have a sudden inflammation of the mixture, accompanied by a report. No great noise is made when only a small volume of coal gas and air is exploded in this way, and I think it is for this reason. The flame has to travel a considerable way down the cylinder or tube containing an explosive mixture of coal gas and air, before what is now known as

the explosive wave is propagated, and as this is a matter of very great importance, I should like to say a few words upon it.

Until four years ago, the rate at which a mixture of oxygen and hydrogen was supposed to burn down a tube filled with it, was 34 metres, or 37 yards, a second. This was the determination of Professor Bunsen, of Heidelberg. The rate at which flame travelled down a tube filled with carbonic oxide and oxygen was found by Bunsen to be only a little over one yard a second. The investigations of M. Mallard brought out this conclusion in the case of coal gas and air, the maximum velocity of explosion was obtained when one volume of coal gas was mixed with five of air, and that velocity was about three feet a second, or about the same pace as the velocity of explosion of carbonic oxide and oxygen. Berthelot was the first who showed that these rates of explosion were enormously under-rated. About the same time, but shortly afterwards, I was experimenting on the explosion of gases, and a question arose as to the effect of a small quantity of a particular gas on the explosion of two others. To determine that, I thought it would be a good plan to measure the velocity of the explosion of these gases with different quantities of the third. I arranged an apparatus to measure this explosion, but I found the rate of explosion was infinitely greater than I had the means of measuring. Whereas I was thinking to measure a velocity of three or four yards a second, the explosion that happened in my tube certainly went hundreds of yards a second, and I was totally unable to measure it. I saw, at all events, that the explosion was vastly quicker than was supposed. Shortly after I did that work, I came across Berthelot's paper which was just published. He found that hydrogen and oxygen exploded at the rate of more than 1,000 metres a second. I determined to repeat these experiments, and put up a very delicate apparatus for the purpose. I am happy to say that my results come out exceedingly concordant with the later results of Berthelot. I used a tube 200 feet long, and near each end of the tube stretched a narrow strip of silver foil, which formed part of an electric circuit. When they were broken by the passage of the flame, a current passing through two electro-magnets was interrupted, causing the release of two styles, which made their mark on a moving plate. M. Berthelot employed pieces of tin-foil, and placed in them a grain of fulminate, so that when the flame passed by, the fulminate exploded, and destroyed the tin-foil. I did not introduce this extra explosive, but trusted to that which the explosion was perfectly capable of doing—the immediate destruction of the silver foil by the passage of the flame. I found as the mean of my results that a mixture of oxygen and hydrogen in a pure state, two volumes of hydrogen to one of oxygen, exploded at the rate of 2,817 metres a second, over 3,000 yards; this number being the mean of six experiments. The mean of Berthelot's experiments is 2,810. This is a very close concordance, and I think will be regarded by chemists as satisfactory, showing that the velocity has been measured within a very small fraction of the truth. When you light a mixture of hydrogen and oxygen in the eudiometer, the explosion does not acquire this pace at once, but the gases begin burning slowly, and they gather pace as they go along, for each layer is compressed by the burning layer above it, and each layer burns at a higher and higher pressure, until finally such a pressure is reached that the layer submitted to it is brought up to the ignition point by the heat produced in its compression. The layer below that is also brought up to the ignition point in a similar manner, by compression, and thus a constant rate of ignition is maintained. In the case of hydrogen and oxygen the explosion has only to go a few inches in order to establish this constant "explosive wave." In the case of carbonic oxide of oxygen, Berthelot found as the mean of his experiments a rate of about 1,000 metres, but I found a rate of over 1,500 metres. I discovered that the space given to this mixture by Berthelot to aquire its final velocity was not sufficient; carbonic oxide and oxygen require nearly a yard before they acquire this maximum rate. I have not yet ascertained the explosion rate of marsh gas, as I have only made one experiment on it, but it is something over 2,000 metres a second. Now these velocities are very considerably diminished when we burn the gases in air instead of oxygen. The nitrogen of the air interferes with the action because it itself has to be heated up to a high temperature, and, therefore, prevents the other gases reaching such a high temperature as they otherwise would. Therefore, the velocity of the explosion of coal gas in air is very considerably less than the velocity of the explosion of coal gas in oxygen. I do not know the velocity with sufficient accuracy to give you a number tonight, but it is very considerably greater than that which has been assigned to it.

I can show you an experiment with coal gas and oxygen, to compare with the one you saw just now with a mixture of coal gas and air. You saw then that at the extreme limits the mixture just burnt, but there was no noise; at the maximum explosiveness the flame traversed the vessel very quickly, and there was a sharp whistling sound. Here is a little of the same coal gas mixed with oxygen. The loud report which follows the application of a light to this mixture marks the great difference between the burning of coal gas and oxygen, and the burning of coal gas and air.

Now, the products of combustion of coal gas—leaving out for a moment the carbon bi-sulphide—are steam and carbonic acid. The steam is poured out into the atmosphere and mixes with it. If there is an excess of it, and the room is small, there is condensation of the steam on the sides of the room; but in an ordinary room, with ordinary ventilation, you do not have condensation of steam. In the carbonic acid you have a gas which is poured out into the room, mixes with the air, and is carried away in the ordinary processes of ventilation. Steam is considerably lighter than air—roughly speaking, half as light. Carbonic acid is heavier than air. I can easily show you some of the properties of carbonic acid. It is most readily prepared by taking some powdered chalk, and pouring on to it some acid which liberates the carbonic acid. We can easily fill up a beaker with the gas. We find that when we bring a taper into it, it is immediately extinguished. Carbonic acid being heavier than air, I can dip up some of it with a cup, and pour it into another vessel. It pours rather slowly, as it is not much heavier than air. If I have poured any into this vessel I shall have it down at the bottom, and we will let a light down to see. You see the jar is two-thirds full, and extinguishes the light at once. Carbonic acid, then, is an invisible colourless gas, heavier than air. One can take it up in a cup, pour it from one vessel to another, and it extinguishes a taper. It has the property of forming a milky precipitate with lime water, which is the usual test for it. I dip out some of this gas, pour it into a cylinder, and shake it up with lime water; immediately we get a milkiness due to the formation of carbonate of lime, from the union of the transparent lime water with carbonic acid gas. If we place a large vessel over a gas flame we are able in this way to get some of the products of combustion. We can shake up the contents of the vessel with lime water in the way I did just now, and we get the same milkiness as I got before when I mixed the carbonic acid with it. The carbon of the gas unites with the oxygen of the air to form this same gas, carbonic acid. The two products of combustion of coal gas, steam and carbonic acid, are both gases. Steam is a condensable gas, but carbonic acid is not at ordinary temperatures.

Just a word about this other constituent of coal gas and its product of combustion. Carbon bi-sulphide exists in very small quantity in coal gas, and is due to the sulphur in coal. We cannot get coal without some sulphur in it, and in the distillation of the coal, part of the sulphur of the coal unites with the carbon to form this volatile carbon bi-sulphide, which mixes with the other gases. Most of the sulphur in coal unites with hydrogen, forming sulphuretted hydrogen; but there is no difficulty in stopping the sulphuretted hydrogen in the purifiers. The carbon bi-sulphide, however, is more difficult to stop; part of it always comes over, and I believe at present, in London gas, there are about 12 grains of sulphur as carbon bi-sulphide in 100 cubic feet of coal gas. This carbon bi-sulphide, when the coal gas is burnt, burns to sulphurous acid; that sulphurous acid somewhat resembling carbonic acid in its chemical properties. It mixes with the air, but under some circumstances it is capable of oxidation to sulphuric acid, and sulphuric acid is injurious to various things which we have in our rooms.

Now there has been a good deal of dispute as to the nature of the change by which the sulphurous acid coming from a gas flame is changed into sulphuric acid. It has been asserted on the one hand that sulphurous acid, in the presence of steam and the oxygen of the air, is readily converted into sulphuric acid; that you have formed in the atmosphere of a gas-lighted room a cloud of sulphuric acid particles, which are then deposited upon all substances in the room. But, on the other hand, it has been asserted that this could not be the case, for sulphuric acid is only found deposited on hygroscopic substances, and not on all substances in the room indiscriminately. The latter is, I think, the correct view. I think so for this reason; if sulphurous acid and oxygen are brought together and warmed up, they do not unite; they do not unite at the temperature of boiling water. If sulphurous acid and steam—not water, but steam—are brought together, they do not unite. They do

not form a molecule of hydrogen sulphite, but they continue to exist as separate gases. Again, if sulphurous acid, steam, and oxygen are brought together and warmed up, so long as the steam remains in a gaseous state, the sulphurous acid does not suffer the slightest trace of oxidation. I have experimented on this matter carefully. I have mixed these gases in a eudiometer, having measured them before mixture, and I have kept them in the eudiometer at temperatures varying between 0° and 100, and so long as no water was condensed on the side of the eudiometer, there was no trace of sulphuric acid produced. So that the sulphurous acid coming from the burning of the coal gas in the air, does not suffer what has been called aërial oxidation by steam and oxygen. It is only when that sulphurous acid meets with water, that is to say damp surfaces, that it suffers oxidation. Now what happens in a room lighted with coal gas containing sulphurous impurities? If there are hygroscopic substances in the room, if there are damp walls, if there are basins of water about, if there are certain things like very dry leather, which readily take up water, the water will dissolve the sulphurous acid, and form hydrogen sulphite. Now hydrogen sulphite in a liquid state, that body which we may represent by $H_2 SO_3$, very readily suffers oxidation. So that you find, if you put a basin of water in a room lighted with a sulphur-laden gas, that you get the water gradually converted into hydrogen sulphate. Metal-work close over a gas burner condenses steam for a short time after the gas is lighted. The trace of sulphurous acid dissolved by this water is oxidised to sulphuric acid. Every time the burner is lighted the process is repeated, so that, in the course of time, a considerable quantity of sulphuric acid is formed on the metal. If you examine the bindings of books which have been placed up near the ceiling, and have got rotten through heat, you find sulphuric acid there. But I do not think for a moment that sulphurous acid was the cause of the rotting the book-binding; I think the rotting was caused by heat; that the bindings having rotted, then became hygroscopic, and condensed water; that the water dissolved the sulphurous acid, which then was readily oxidised to sulphuric acid. I know people say that, on entering a gas-lighted room, where there is a large per-centage of sulphur, they can smell sulphurous acid; and I do not doubt that for a moment—I believe they can. But I call their attention to this fact, that the quantity of carbon bi-sulphide in the gas is only a mere trace, and that the quantity of oxygen required to burn coal gas is more than the coal gas itself; roughly speaking, 100 volumes of coal gas require 130 volumes of oxygen. Then, since the oxygen is one-fifth of the atmosphere, every 100 volumes of coal gas requires 640 volumes of air; and, therefore, if you are burning coal gas in a room, and do not wish to be suffocated, you must allow this air to come into the room, and the products of combustion to pass out. If you do that, if you supply for every 100 feet of the gas you burn, the 640 necessary feet of air, then I say that that air in the room can never become saturated with aqueous vapour, and no sulphuric acid can be produced, except in the manner above described.

ADDITIONAL LECTURE.

ON THE PAINLESS EXTINCTION OF LIFE IN THE LOWER ANIMALS.

By Benjamin Ward Richardson, M.D., F.R.S.

Delivered Tuesday, December 18, 1884.

During the latter part of last and the early part of the present year, I constructed at the Dogs' Home, Battersea, at the request of the committee of that institution, a lethal chamber for the painless extinction of the life of the animals which have, of necessity, to be destroyed there. I put the process first into operation on Monday, May 15, by subjecting thirty-eight dogs to the fatal narcotic vapour. They all passed quickly into sleep, and from sleep into death. Since that time, up to the present time, a period of seven months, the lethal chamber has been regularly in use. From 200 to 250 dogs per week have been painlessly killed in it, or a total of nearly 7,000.

The results of this procedure have been so exceptionally large, and so entirely practical and successful, the time has now come when they ought, I feel, to be brought fully into public record before this Society. I say specially this Society—the Society of Arts—because it has become by age and by nature, in England, the happy hunting ground of happy inventions, a kind of literary record office, in which the scholar of the future will find some notice of almost every discovery and mechanism which has in our time been constructed

for the benefit of man and of his humble companions of the lower creation.

In this lecture I shall deal with four subjects :—

The history of the lethal process.

The lethal process in its present application.

The relation of the lethal process to other processes having the same object.

The extension of the lethal process to the slaughter of animals intended for food.

The History.

The history of the lethal process, for extinguishing the lives of the lower animals, may be very briefly told. It follows, as a natural and practical result, upon the process of anæsthesia for the human subject about to undergo a surgical operation without feeling the pain of the operation. It is, in fact, such anæsthesia, but with this difference, that whereas in ordinary anæsthesia for an operation, the operator allows the subject who has been narcotised to return from his deathly sleep into the communion of life, in the case of the lower animals placed in the lethal chamber, the administration of the anæsthetic is sustained until the induced artificial sleep becomes the veritable sleep of death. In about one instance in three thousand it occurs, by accident, to man under chloroform that he dies in the same way. From the borrowed semblance of "shrunk death" he passes, usually, without a struggle, when the sad accident occurs, into actual dissolution.

The thought of applying the anæsthetic method to the painless destruction of the lives of the lower animals, and the first accomplishment of it, came from myself, and dates back as far as the year 1850.

In that year, I constructed at Mortlake, where I was then starting in practice, a small lethal chamber, to which my neighbours would frequently bring animals which they wished to have killed. In 1854, I began to illustrate this mode of painless death, and from that time up to 1871, I never allowed the subject to rest. In 1871, I brought it formally before the Medical Society of London, at the opening meeting of the 99th session, in a paper, afterwards published separately, entitled "Note of a Preliminary Research to Discover a Practical Method of Killing Animals without the Infliction of Pain." In this paper I discussed other modes than the lethal, to which I will refer under the third head of the present lecture.

About this same time I made, through Mr. Colam, a communication to the Royal Society for the Prevention of Cruelty to Animals on the same design, and suggested a mode for killing painlessly dogs and cats that were wounded in the streets, and I have to thank the committee of that society, and Mr. Colam, for the interest they took in my endeavours.

From that time downward to the present I have continued the inquiry, making use of all the known anæsthetic substances, in order to ascertain which was cheapest, most adaptable, most certain in action. The information, thus obtained, proved very useful when the time came for utilising it. That time came last year, when Mr. Kennett was good enough to offer the sum of £200, in order to enable the lethal method to be carried out at the Dogs' Home, where, as I have already said, it is now in operation.

The Lethal Process in its Present Application.—Details.

In undertaking the practical act of carrying out lethal death on the large scale required at the Home, I had to determine, in the first place, on the anæsthetic or anæsthetics to be used, and, in the second place, to construct the room or chamber in which the animals should be confined while exposed to the lethal gas or vapour

The Anæsthetic.

I have placed on the wall a table of anæsthetics, including most that have, up to this time, been discovered, with a general outline of their respective properties and values. There is, you see, a goodly list, twenty-two in all. Out of these I selected, as shown by experiment to be the best, four.

Carbonic oxide.

Chloroform.

Carbon bisulphide.

Coal gas.

Carbonic Oxide.—I was led to carbonic oxide, not only by reading of it, and by witnessing the effects of it as a poison when it has been breathed from coke fumes, but specially from studying its action when evolved from the fumes of the *Lycoperdon giganteum*, or common puff-ball. The fumes as thus evolved, have been employed for centuries past by the common people for narcotising bees before taking the honey from the hive. A portion of the substance being burned under the hive, the bees, inhaling the fumes, fall into a deep sleep, during which time they are unconsciously deprived of their industrious earnings. I was so struck with the perfect action of these

TABLE OF ANÆSTHETIC GASES AND VAPOURS.

Name of Substance.	Elementary Composition.	Material Condition.	Gas or Vapour density H = 1·	Fluid Density water = 1·	Boiling point. Cent.	Boiling point. Fahr.	Physical Qualities.
					Deg.	Deg.	
Nitrous oxide	NO	Gas	22	...	...	...	Supports common combustion: sweet, and not irritating to breathe.
Carbonic oxide	CO	Gas	14	...	...	...	Burns in oxygen; not irritating to breathe.
Carbonic acid...	CO_2	Gas	22	...	...	...	Extinguishes flame; irritating to breathe.
Bisulphide of carbon	CS_2	Fluid	38	1·270	43	107	Vapour burns; odour disagreeable unless well purified.
Hydride of methyl (marsh gas)...	$CH^3 H$	Gas	8	...	...	...	Burns air; inodorous, not irritatin
Methylic ether	$C^2 H^6 O$	Gas	23	...	...	...	Burns in air; almost inodorous when pure.
Methylic ethyl ether	$C^3 H^6 O$	Fluid	30	...	11	52	Burns in air; ethereal odour; rather pungent.
Chloride of methyl	$CH^3 Cl$	Gas	25·25	...	...	...	Burns in air; rather pungent.
Bichloride of methyline	$CH^2 Cl^2$	Fluid	42·5	1·320	40	104	Vapour burns; pungent odour.
Chloroform	$CH Cl^3$	Fluid	59·75	1·480	61	142	Vapour extinguishes flame; pungent odour.
Tetrachloride of carbon	$C Cl^4$	Fluid	77	1·560	78	172	Vapour extinguishes flame; odour fragrant, not pungent.
Hydride of ethyl	$C^2 H^6 H$	Gas	15	...	...	...	Burns in air; inodorous.
Ethylic ether (absolute ether) ...	$C^4 H^{10} O$	Fluid	37	·720	34	93	Burns in air; pungent to breathe.
Chloride of ethyl	$C^2 H^5 Cl$	Fluid	32·25	·921	11	52	Burns in air; ethereal odour; rather pungent.
Ethylene (olefiant gas)	$C^2 H^4$	Gas	14	...	...	...	Burns in air; pleasant to breathe.
Bichloride of ethylene (Dutch liquid)	$C^2 H^4 Cl^2$	Fluid	49·5	1·247	80	176	Vapour burns; ethereal odour; rather pungent; smoky.
Chlor-ethylidene	$C^2 H^4 Cl^2$	Fluid	49·5	1·174	64	147	Vapour burns; ethereal sweet odour; pungent.
Bromide of ethyl (hydrohomic ether	$C^2 H^5 L^2$	Fluid	54	1·400	40	104	Vapour rather pungent, but pleasant.
Hydride of amyl	$C^5 H^{11} H$	Fluid	36	·625	30	86	Vapour burns in air, inodorous when pure.
Amylene	$C^2 H^{10}$	Fluid	35	...	39	102	Vapour burns in air; pungent; smoky.
Hydrocyanic acid...	$HC N$	Fluid	...	·705	26	70	Vapour painful to breathe; special; suffocating odour.
Coal gas	...	...	...	...	...	...	Gas at first slightly irritating, but quickly narcotic.

fumes after being shown one of these experiments, that, in 1854, I introduced the fumes for anæsthetic purposes. Purified by being passed through water, they produced the most rapid narcotism, under which many operations were performed painlessly on the inferior animals. The question was the character and chemical nature of the agent in the fumes which produced the anæsthesia. The late Dr. John Snow, so well known for his immense labours on anæsthetics, and the late Mr. Thornton Herepath, one of our most promising chemists, were each separately engaged in discovering the concealed gas or vapour. Snow and Herepath ran ahead of me in the inquiry. They, simultaneously, but by quite different methods of research, arrived at the fact that the narcotic present was carbonic oxide, or the same gas as is produced during the combustion of carbon or coke in a limited supply of oxygen.

These researches led me to study the action of this gas in its pure form, and to the discovery of many curious facts relating to it. Amongst other things, I noticed that, like oxygen, it made the venous blood of a bright red colour, and that warm-blooded animals exposed to it for a long period of narcotion are rendered temporarily diabetic.

I did not, on the whole, think it commendably safe as an anæsthetic for man, but I fixed upon it at once as one of the best and cheapest of lethal agents for the painless destruction of life in the lower creation. It is the principal agent for this purpose which I have used since the date named above, 1854.

Carbonic oxide is a gas, and if quite pure is so odourless and produces so little irritation, that when present in the air, it is apt to be breathed unconsciously until the effects of it are felt. Those who by accident have been narcotised by it, and have recovered from the effects, have expressed that they had no recollection of anything whatever, that they passed into sleep in the ordinary way of sleeping, and knew no more.

The gas can be made in two easy ways. (1.) It can be made simply by passing air or oxygen over burning coke or charcoal. If air be used, the product consists of carbonic oxide, with some carbonic acid, and with the nitrogen of the air, which passes through the furnace unchanged. As the nitrogen forms four-fifths of the air, the product is, of course, very much diluted. A hundred cubic feet of an atmosphere so produced does not contain more than 15 per cent. of the gas. Such an atmosphere is, nevertheless, very deadly, because the nitrogen, entirely negative, has no power of sustaining life. When oxygen is used alone in limited quantity the gas is turned out practically pure. By either mode—by common air or oxygen—one pound of charcoal should yield 31 cubic feet of the lethal gas, assuming that the combustion is correctly carried out.

(2.) The second mode of making the gas is by passing carbonic anhydride, still commonly called carbonic acid, over red hot charcoal. The charcoal in this instance is placed in a tube, into which the carbonic acid, CO^2, can flow. The tube is put into a furnace, the charcoal is made red hot, and while in this state the carbonic acid passes over it. The carbonic acid is thus deprived of one part of its oxygen by combination of oxygen with the heated carbon, and carbonic oxide escapes at the exit of the tube. The gas thus formed is practically pure, and is very deadly. If even a little carbonic acid does pass over in its free state, the lethal action is sustained, carbonic acid being itself a gas destructive to life.

Chloroform. — I was naturally led to chloroform, by reason of its common use as an anæsthetic. There is no anæsthetic more certain in its action, and none more certain to kill if it be administered in a determinate manner. Administered even with skill, so as not to kill, it proves accidentally fatal about once in 2,500 times, and so soon as air is charged with over ·5 per cent. of its vapour, it is not breathed without danger. Death from it is very determinate when it occurs, and seems to be entirely painless.

The vapour of chloroform does not burn. On the contrary, it extinguishes flame. If we plunge a lighted taper into a jar through which the vapour of chloroform has been diffused, the light is at once extinguished. I shall show, in the sequel, that this has a certain useful bearing on the subject now before us, apart from the matter of fatal narcotism.

Chloroform, being purchaseable as a chemical fluid, I need not refer to its manfacture. When we use it for narcotism, we merely diffuse the fluid into the state of vapour, and make provision for the vapour to be absorbed by the lungs of those subjected to it. It produces little irritation when breathed.

Bisulphide of Carbon.—The bisulphide of carbon is a very rapidly-acting anæsthetic. It produces narcotism, in fact, almost as quickly as carbonic oxide, and with less muscular commotion. The vapour of it burns in air in

a light be brought near to it, but when its vapour is mixed with that of chloroform, this danger is avoided. It is bought as chloroform is, in the fluid state, and can be obtained, therefore, from the chemist directly, ready for use, by diffusion of its vapour. It has one immense advantage, that of being excessively cheap; and it has one great disadvantage, that of being excessively unpleasant in regard to its odour, unless it be most carefully purified by repeated distillations. Combined with chloroform, with which it mixes freely, the peculiar odour is largely reduced, and by pouring the mixture over chloride of lime, is almost entirely removed. For this reason, together with that relating to the difficulty of combustion of the combined vapours, I have used largely in these researches the mixture of chloroform and carbon bisulphide. The combined vapours produce also a singularly good antiseptic atmosphere. Specimens of the chloroform-bisulphide compound are on the table.

Coal Gas.—Common coal gas is one of the most potent of narcotising gases. I pointed this fact out in the very early days of anæsthesia. The gas is a compound of four gases, three of which are excellent narcotics, and one a negative gas. It contains 47 per cent. of hydrogen, 42 of marsh gas, 3 of heavy hydrocarbons, and 8 of carbonic oxide. All these gases are anæsthetic in their action; marsh gas is one of the best, and carbonic oxide is one of the quickest; but they are all explosive.

For the lethal purpose, nothing could possibly surpass coal gas. I put it freely to the test, and found it was all that we could desire. In an atmosphere containing 25 per cent. of this gas, an animal goes to sleep in from two to three minutes, and dies asleep as easily as in any narcotic vapour or gas whatever. The gas is always at hand, and for the present purpose is the cheapest and readiest of all. Used in the lethal chamber at Battersea, 100 dogs could be put painlessly to death at the cost of a shilling, and without any more trouble than that of turning on and off the gas.

Under such circumstances, it seems absurd to think of going any further for a narcotic agent. And yet it is necessary, at all events, when a large lethal chamber is wanted, on account of the danger from explosion. I feel so sure that an accident by explosion would occur from the frequent use of the gas in this manner, that I dare not undertake the responsibility of recommending it, except on a smaller scale, which has yet to be considered. A man smoking his pipe near the chamber, or carrying a light, or striking a match, might lead to the accident, or the spark from the friction of the wheels of the cage carrying the animals with the tram beneath them, and on which they rub, might cause the accident.

I hoped at one time that I had overcome this risk by the very simple expedient of letting the gas pass into a chamber through chloroform. The vapour of chloroform mixing with the gas would, I believe, prevent explosion, even if a flame were introduced. I therefore combined the gas with the chloroform, and found in the combination not only a splendid narcotic, but apparently a safe one in regard to explosion. I was disappointed. I narcotised an animal to death in a mixed atmosphere of coal gas and chloroform, and that both easily and safely. The chamber containing the animal was left for three hours, and at the close of that time the gas in it was not explosive, the vapour of the chloroform controlling the combustion. But the following morning, on striking a light in the chamber, the gas took fire with considerable force. During the coldness of the night, the vapour of chloroform had condensed, and left the gas free.

After this experience, I gave up the idea of using coal gas on a large scale. I think it may be useful in a small apparatus under some circumstances, but I would not, while admitting its many advantages, dare to recommend it as of general application.

All things considered, I was led to conclude that carbonic oxide was the best narcotic agent to employ, combining it with chloroform or carbon bisulphide if that should prove necessary. Deciding on this point, the next question was how to manufacture the carbonic oxide so as to bring it into practical use on the easiest as well as the largest scale.

I designed originally for the trial at Battersea to erect two large reservoirs, to set up an apparatus for the generation of carbonic acid, and a furnace by which this gas could be transformed into carbonic oxide. By making the carbonic oxide in this way, and charging the gas-holders with it, it would be at hand at all times to be passed into the lethal chamber.

There were difficulties in the way of carrying out this design. The first of these were the expense and the skill required to work the apparatus. The reservoirs alone would have cost a hundred pounds, and when fixed would

have taken up a great deal of room; a skilled man would at the same time always be wanted to charge them and keep them in proper order.

These difficulties led me to keep to the original plan of a simply constructed stove, in which the gas should be made by burning charcoal. Here, however, when I got into experiment, I found several new difficulties which had to be removed.

The burning of charcoal in an ordinary stove produced sufficient of the gas, but the heat of the gas was such as to demand a means of cooling it before it should enter the chamber. There was also produced in the combustion, so much vapour of water, that the experimental small chamber with which I first manipulated was charged with steam, which condensing, left the walls of the chamber loaded with water, a condition most unfavourable to narcotic action, and destructive to the walls of the chamber itself.

While studying the best means of overcoming these objections, and after failing to overcome them by several methods, I luckily recalled Mr. Clark's condensing-stove. This stove, with which I have no doubt most of you are conversant, is a most ingenious invention. The fumes proceeding from the combustion in the furnace, first ascend and then descend through two lateral columns, to escape by a tube directed over a trough or saucer. A large quantity of water vapour is in this way condensed, and is collected at the base of the stove, together with substances, derived from the combustion, which are soluble in water. Here, with a little modification, was what I wanted. To adapt the stove to my purpose, I got Mr. Clark to make a charcoal furnace over a gas-burner, so that, when the charcoal was laid in the furnace, it could be instantly set alight by merely turning on and lighting the gas, letting the flames of gas play through the charcoal. Next I got him to make a large condensing cistern beneath the stove, with an opening from it to convey the carbonic oxide by a tube into the lethal chamber, and with a tap, by which the condensed fluid could be drawn off. The arrangement answered straight away, if I may so say. The immediate combustion of the charcoal by the gas, yielded very nearly the theoretical value of the product, carbonic oxide. The gas was deprived of water by the condensation; it was delivered over to the chamber with a steadiness sufficient for all practical necessities; it was cooled without any other artificial means, so as never to raise the chamber above summer heat; it was produced cheaply; and it afforded such simple action, that any workman could at once learn to use it. It is just to say that the immediate success which has followed my efforts has been much expedited by the use of the Clark condensing-stove.

Another useful result springing from the employment of this stove was, that it enabled me to diffuse other narcotics into the chamber, by merely allowing the warm gas proceeding from the stove to pass over a porous surface, charged with the narcotics, on its way into the chamber. So much for the narcotic to be used, and the production of it. I have now to pass to the method of applying it.

The Lethal Chamber.

To apply the narcotic gas or vapour, it is necessary to have a closed place in which the animals are exposed to the narcotic, and another place in which they are collected preparatory to being subjected to the narcotism. This implies what I have called the lethal chamber, and a cage.

At Battersea, it was necessary to have an apparatus large enough to narcotise as many as one hundred dogs at a time. It was, therefore, essential to have a large lethal chamber, and one that was strong and effectively constructed. I noted down at the beginning the following requirements, all of which I had calculated out of a series of preliminary studies, and constructed on a small working scale.

1. The chamber, of whatever substance built, must be so constructed that its interior shall not be subject to great variations of temperature. This I knew to be very important, since in observing the action of narcotic vapours on the human subject, I had learned that humidity and cold materially interfere with their quick action, while dryness and warmth favour such action. In a lethal receptacle, such as was being constructed, there could be no certainty whatever, unless the temperature and dryness were at all times uniform.

2. It was necessary so to construct the chamber that sufficient but not an excess of room should be allowed in it for the expansion of the gases introduced. It might seem at first sight, and before inquiry was instituted, that the more the space within the chamber was reduced, the quicker would be the effect. This, however, is not practically the fact. In order to secure perfect diffusion of the narcotic atmosphere, the space to be filled with it must be about one-eighth greater than is absolutely

required for a cage, fully charged with the animals that have to be killed.

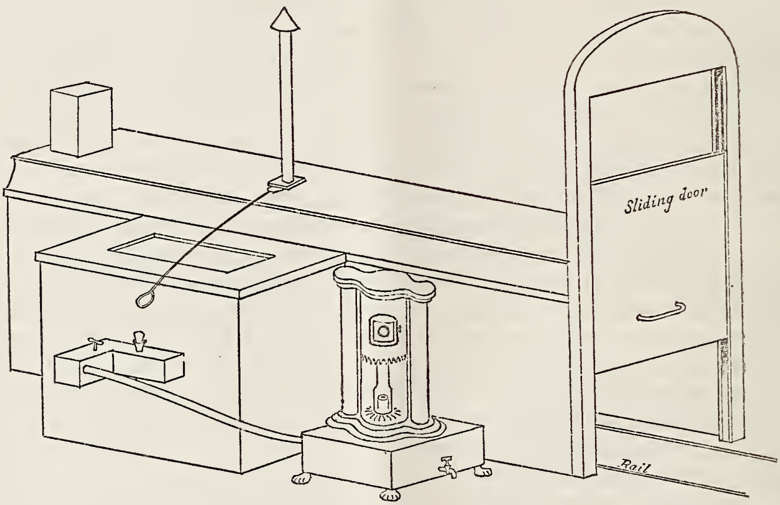
3. Much care is required in connecting the stove with the chamber, so as to make sure of equal diffusion of the gases or vapours through the enclosed space. Unless this equal diffusion is rendered effective, some of the animals are more exposed to the vapours than others. and the effects are irregular, which is as bad a result as could possibly be obtained.

4. It was essential to provide that a sufficient quantity of the narcotic should be introduced before and for a brief period after the introduction of the animals.

5. It was requisite to invent a plan by which the chamber could be kept completely closed until the precise moment when the animals have to be introduced, then instantly opened for the introduction, and as instantly closed after the introduction. It was equally requisite to guard the entrance into the chamber, so that the men employed in pushing in the cage should be protected from the vapour. A method had also to be adopted by which it could be known when all the animals had ceased to breathe.

To meet the first of the above-named conditions, I constructed the lethal chamber (the outline of which is shown in Fig. 1) of well seasoned timber, making every part of it a double wall, and filling the interspace closely with sawdust. The plan has answered all my expectations, and, with wood as the material

Fig. 1.



The Lethal Chamber.

for construction, I doubt if it can be improved upon. Should iron ever be used, and I can imagine that it is sure to be, it will be essential to have a double wall, and to fill up the interspace with a layer of Croggon's felt, an inch in thickness, or with the slag felt which was brought before the notice of this Society when I was delivering the Cantor course on the preservation of animal substances. Every part of the construction ought to be, in this manner, double lined. Should the chamber be built in brick, the wall should be of 9-inch thickness, and of glazed brick in the interior. I am of opinion that a well-built brick chamber would answer excellently well. The roof of such a place should either be an arch of brick, or iron, or wood, closely covered with felt. An inner lining of wood, covered with felt, and overlaid with galvanised iron, would be very effective.

In order to obtain the slight excess of space which was wanted to insure diffusion, I formed on each side of the chamber an extra space, which I call a pocket. The spaces, one on each side, were at first too large, and I had to reduce them, from the inside, to the size I have already indicated as the best. They are in the centre on each side, and stand out as aisles from a central nave.

In order to secure quick and equal distribution of the vapours through the chamber from the stove, I let the gases in at first from the top, under the impression that the gases, being heavier than the atmosphere, would be made to pass with greater rapidity into all parts. Theoretically, this view is correct; but

as it became necessary to have two floors or tiers to the cage, I was obliged, in the end, to let in the gas half way down the sides of the chamber. By using two stoves, one on each side, this method of introduction was both convenient and effective; I do not think it could be better, however altered. To remove the common air, an opening, with a shaft of ten feet, was made in the roof. The shaft has a bore of three inches, and has a cap at the top, in order to prevent down currents of air. At the foot of the shaft is a damper, which can be opened and closed at pleasure. The directions to the managers are, to open the damper when the stove is first lighted, and let it remain open for half-an-hour; then to close it partly for another half hour, and after that to close it entirely, and not to re-open it until the chamber is again required.

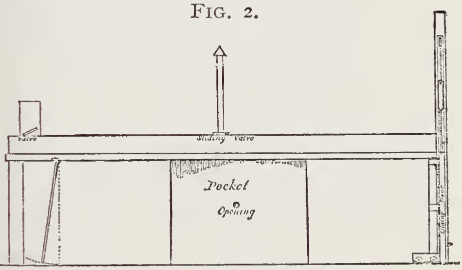
To meet the fourth necessity, a plentiful supply of the narcotising vapour, two stoves have been connected with the chamber, each capable of burning two pounds of charcoal per hour, and giving up the products of the combustion into the chamber. At first—guided by the general, but not quite correct, impression as to the extremely poisonous qualities of carbonic oxide—I was content with one stove, but found it not quite sufficient, for although it delivered fifty cnbic feet of the gas per hour, it acted too tardily to suit my wishes. I therefore added a second stove, which was abundantly sufficient.

To make the narcotic effect still more certain, and to keep the chamber at all times lethal, I made an extra provision. At the two points where the tubes from the stoves enter the chamber, I have interposed two strong boxes made of elm, and covered with thin lead. These boxes, which are 18 inches long, and 4 inches broad, are filled loosely with the porous burnt loam, known as Verity's patent gas fuel, an excellent substance for filling a grate where coal gas is burned instead of fuel. This substance is so porous, it takes up narcotic fluids most readily, holds them in its pores, and gives them up in volumes of vapours when warm gas is passed over it. Into the boxes closed in with this fuel there is a funnel, opening at the top, for supplying the fluid, which can be shut with a stopper; and at the end of the box, standing out at a right angle from it, is a continuous section, in which there is a large tap, for regulating the currents of gas from the stove.

When the stoves are in action, the tap is turned on, and the gases from the stove pass through the boxes over the patent fuel into the chamber. Nothing more is done until just before the time when the animals in the cage are to be introduced. Then ten fluid ounces of an anæsthetic mixture, consisting of equal parts of methylated chloroform and carbon bisulphide, are poured upon the fuel through the openings in the top of the little boxes, the openings being immediately closed. After the animals are in the chamber, ten ounces more of the same mixture are added, and if, after three or four minutes, any of the narcotised animals are still breathing, ten or twenty fluid ounces more are poured in. This is not often necessary, but, for reasons which will be explained, it is occasionally.

In pushing the charged cage into the chamber, there is naturally a very great displacement of gas or vapour within. The cage has a cubic dimension of 160 cubic feet, and the chamber, with the side spaces, is 200 cubic feet. To put in the charged cage was, therefore, equivalent to displacing more than half the narcotic gas or vapour which it contained. As a consequence, it was necessary to provide an exit which would save strain on the walls of the chamber, and would let out a little gas without letting in common air. The task was one which called for considerable patience and trial of method. I met it at last by the plan shown in Fig. 2, which exhibits the chamber in

Fig. 2.



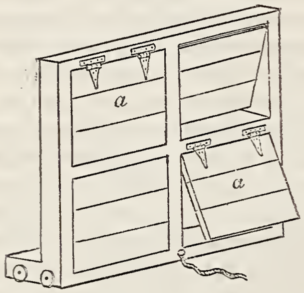
Reduced Section of Fig. 1.

section. Two feet from the far end of the chamber, there is suspended from the top a light hanging screen, which reaches within four inches of the floor. Behind this screen, and in the roof of the chamber, is a shaft, with a valve opening upwards. As the cage is pushed in, this screen is raised from the bottom, and the air, rushing out at the lower part, ascends behind, and escapes by the valve. The screen is so balanced, that when sufficient air has been extruded, its lower end reaches the back or lower end wall of the chamber. The screen itself thus acts as a

regulating valve, and when the pressure is off, it returns to its level, letting any gas at the rear of it return towards the cage.

To enable the operators to introduce the cage quickly, and at the same time to protect them from the action of the vapours, the following plan, also indicated in the section diagram, is adopted. The door or entrance into the lethal chamber is a slide like the sash of a window. It is placed between two strong uprights, and is balanced by a weight and pulley in each, so that it can be opened and closed with the greatest rapidity. Behind this sliding door there is placed what I call the shield or block. The shield is a framework of wood

FIG. 3.



with four large metal valves, two opening inwards, two outwards. The shield is fixed on a base with four little wheels, and runs easily up or down the chamber. When the sliding door is raised, the moveable valved shield is in position half a-foot within the chamber, and cuts off all escape of vapour. The workmen thus have time to push the cage leisurely, after the door is raised, into the chamber until the end of the cage touches the screen. This effected, they push the cage in a few seconds into the lethal atmosphere, the shield running before it, and then the door is slided down into its place. When all is nicely adapted, a very few seconds are required to introduce the cage and close the sliding or entrance door. When the cage is drawn out the screen is drawn out with it, by means of a cord which is attached to it, and which runs under the cage.

The last requirement which had to be met was the means of knowing when the narcotised animals had ceased to breathe. To get at this fact, the test of hearing was found to be the best. There is inserted into the chamber on one side a long stethoscope, made of bamboo; the mouth of this tube—of trumpet shape—is in the centre of the chamber, just above the cage, when that is in place. The outer part, or ear piece, of the tube stands out four inches on the outside, and is closed when not being used by a solid plug. On listening through this tube, the continued breathing of even a single animal can be detected, and the operators are enabled to determine if it be proper to increase the strength of the narcotic atmosphere, or to stop it.

I have now given all the necessary details of the chamber, and have only to add that it acts so well, I do not think I could improve upon it in principle if I were to construct a new one. The gases act rather rapidly on the metal pipes leading from the stoves, giving rise to some little leakage when the pressure is full on, and rendering it requisite to replace the tubes from time to time. But these are minor details which are a part of all working mechanics, and which call for nothing more than moderate attention and intelligence on the part of the men in charge, who are very soon conversant with all that has to be carried out, and with any defects that may arise.

THE CAGE.

In Fig. 4 (p. 147) will be seen best a description of the cage in which the animals are collected before being put into the lethal chamber. The cage is made of a wooden frame-work, with light iron side bars. It has two sliding doors at the sides, two at one end, and one at the top. It can be filled and emptied through these doors with great rapidity. In order to hold as many animals as possible without discomfort to them, the cage is divided into two divisions or tiers, the flooring of the upper tier being freely perforated with openings, so as to establish a communication between the upper and lower divisions, and allow a due distribution of the gases and vapours used. The cage runs on four 8-inch wheels, which are underneath it, and ply on galvanised iron rails. At the Home there are two cages, in order that one operation of painless killing may follow at once on another if that be necessary.

THE LETHAL PROCESS.

Having now given the details of the mechanism employed, I may describe with advantage the nature of the lethal process. The mode of death to which the animals are subject is that by anæsthesia, not by suffocation or asphyxia. Physiologically, there is a distinctive difference between these modes of death. Death by anæsthesia is death by sleep; death by asphyxia is death by deprivation of

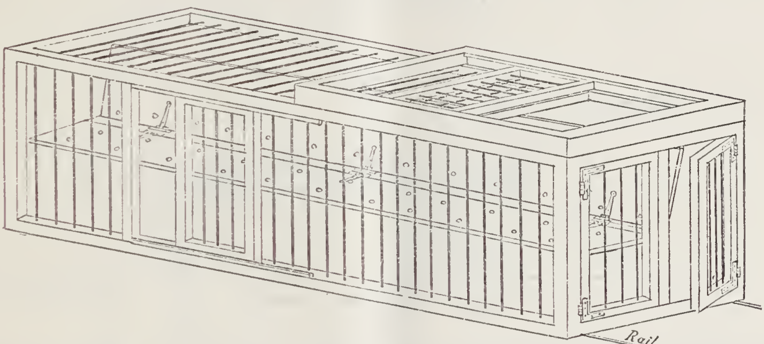
air. Death by anæsthesia is typically represented in death by chloroform; death by asphyxia is typically represented in drowning, or in immersion in carbonic acid gas.

When properly carried out, death by anæsthesia is by far the most certain and least violent of the two processes, although both are probably painless. The anæsthetic is as certainly proved to be painless as any such thing can be proved. In all but fatal accidents from chloroform in the human subject, we know, on the evidence of the persons who have passed through the ordeal, that there is no sense of suffering up to the extremest approach to death; and as we cannot suppose that the lower animals are more susceptible to pain than the highest animal, man, we must consider the death absolutely free of pain. An intense impression of sleep lapses into the sleep that is final.

It is worthy of record, however, that all animals are not equally susceptible to the action of the narcotic vapours. Cats, for instance, lie asleep much longer than dogs before they cease to breathe. They fall into sleep as rapidly as dogs, but do not pass so quickly into the final sleep. In the same narcotic atmosphere a cat will live twice as long as a dog, suffering nothing, and lying in deep sleep, but still breathing.

There is a difference between different animals of the same kind. Some dogs die almost instantly, in fact, as they fall asleep; others fall asleep and continue to sleep for several minutes before they cease to live. In the first observations, before I had rendered the narcotic atmosphere overpoweringly active for all cases, there were a few instances, nine in the first seven hundred, in which the animals slept on from half an hour until an hour after all their comrades had died. Finding out this strange peculiarity, I increased the amount of narcotic vapour until all succumbed very nearly at the same minute, and in the last six thousand there has been no recurrence of the prolonged insensibility. The animals are now commonly all asleep in from two to three minutes, and have ceased to exist in a further period of the same duration. In order, however, to prevent any chance of recovery from the sleep on exposure to air too quickly, the instruction is that the chamber shall on no account be opened until the expiration of one hour after the introduction of the cage.

Fig. 4.



The Cage.

By introducing some other vapours into the lethal chamber with the chloroform, the vapour of hydrocyanic acid for instance, the death, no doubt, could be made more rapid, and indeed instantaneous. To this plan there are two objections, which are, I think, final. In the first place the death would be less peaceful; in the second place, the atmosphere produced would be extremely dangerous to the men employed. On the whole, we could not do better than continue in the course we have hitherto followed.

A Smaller and Portable Lethal Chamber.

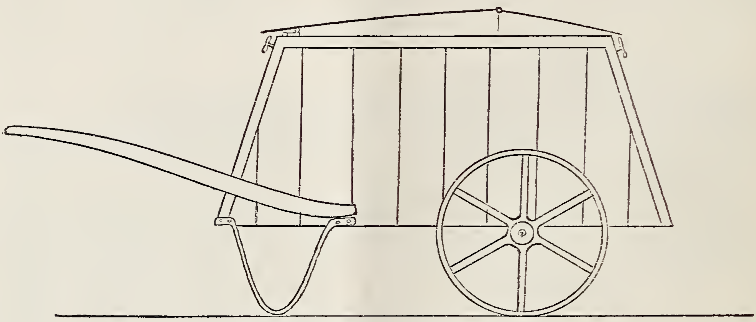
The success of the trial on the large scale has led me to the construction of an apparatus on a small scale, an apparatus which can be moved easily from place to place, which can be kept at different parts of a city or town, at a police station, a veterinary surgeon's, or at any institution that will take it in charge. I entered on the construction of this machine some months ago, with the conviction that I could complete it in a few weeks, and have it ready for use at the Home in cases where only one or two animals have to be destroyed. I am sorry to say that the road to success was not

so easy. I have had, in fact, to construct no fewer than four chambers previous to getting in complete working form what I desired to secure.

The difficulties have arisen from three sets of circumstances. Firstly, that in a portable machine fitted for action at a few minutes' notice, it was not possible have a fire or stove. Secondly, that in order to make the chamber adaptable to animals of different sizes, it was necessary to make it changeable in size. Thirdly, that the substance used for causing the anæsthetic death should be so cheap as to render the process generally applicable. I began by employing coal gas and chloroform, but here, again, was met by the danger of explosion. Then I proceeded to the study of the application of compressed carbonic oxide, which would answer well, but for the expense which would attach to this mode of applying it. Next, I passed to compressed gas with vapour of chloroform and carbon disulphide, but again found the cost too great. Lastly, I fixed entirely on the plan of surcharging common air with narcotic vapour by a bellows, or forcing pump, which answers exceedingly well.

In Fig. 5 there is shown a view of the portable lethal chamber ready for use. It will be seen that the apparatus takes the shape of a closed truck on two wheels, and moveable like a truck or barrow. It measures 5 feet in length, is 2 feet wide, and 2 feet 6 inches high. It moves very easily, and can be managed by one man. It is constructed, like the large lethal chamber, of well-seasoned wood, in double wall, with sawdust filling up the interspace. In Fig. 6 (p. 149), the apparatus is shown in section. As will be seen, there

Fig. 5.



Portable Lethal Chamber.

is one large chamber, having a capacity of nine cubic feet. The chamber opens at the top by a strong lid, swung from behind, which, when brought down, entirely closes up the chamber. Under this lid there is a frame with an opening in the centre, through which baskets or cages of different sizes, and containing the animal or animals, can be let down into the larger space, and held there. This larger space is the narcotising receptacle or chamber.

At the back of the apparatus is a recess in which is placed the narcotising fluid, and the pump for forcing it into the cages containing the animals. The narcotic fluid is contained in a large strong Wolff's bottle filled loosely with Verity's fuel. The forcing pump is worked by a piston from the outside, and consists of a cylinder capable of containing one-eighth of a cubic-foot of air or gas. From the further end of the cylinder are two tubes, one of which runs into the narcotising chamber at the lower part, the other to the long tube in the Wolff's bottle below the surface of the narcotic fluid within the bottle. From the short or escape tube from the bottle is a continuous tube, terminating over the cage containing the animal. By an extra tap, coal-gas can, if desired, be let into this chamber.

Mode of Procedure.

The animal to be slept into death is placed, resting on a little straw or hay, in a cage, which is then dropped into the large receptacle, the lid of which is at once closed. The handle of the piston is then moved up and down at a regular and quiet pace. As the piston is drawn out, the cylinder of the pump is filled with air from the large receptacle, and as the piston is pushed back it forces the air with which the cylinder has been filled through the narcotic fluid, a portion of which it raises into vapour and forces into the cage. Eight strokes of the piston charge one cubic foot of air with the narcotic vapour to saturation, and as there

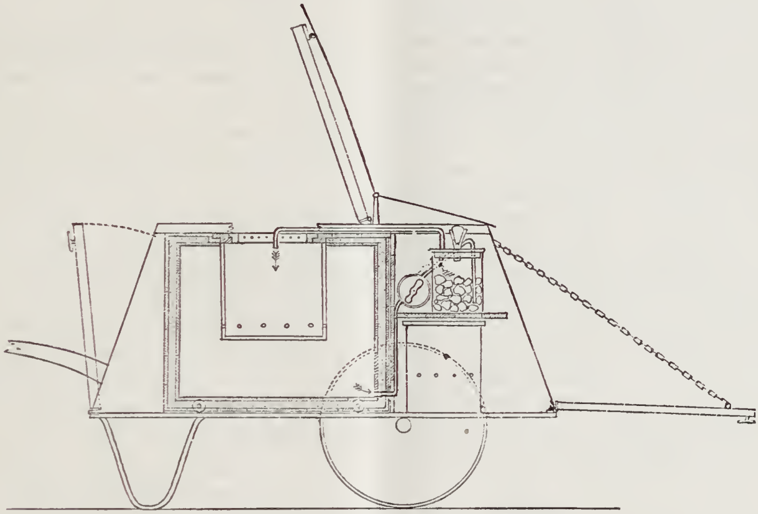
are only nine cubic feet in all to charge, a couple of minutes are sufficient to charge throughout.

The animals in this apparatus pass quickly into sleep, and die not quite so quickly, but quite as painlessly, as in the larger structure.

This smaller apparatus will be so complete when it is finished, that it may be wheeled from the station to a private house, if that be wanted; or it may be used in the streets for giving painless death to wounded animals. It may also, in future, be constructed at so comparatively trifling a cost, that I see no reason why every town in the country may not be in possession of one, and every small animal be spirited away in sleep.

Compared with other modes of extinguishing animal life—such as hanging, drowning, poisoning by prussic acid, shooting, stunning, —the lethal method stands far ahead on every ground of practical readiness, certainty, humanity. I cannot, however, let the opportunity pass of testifying that the method for twenty years carried out at the Dogs' Home, of killing with prussic acid, has been, by the skill and experience of the operators, brought to a great state of perfection and painlessness. The objections to it are moral and physical. It is a tax that few men can usually bear, to have every week to take scores of dogs one after another, and by force administer to each, singly, the deadly poison. Further, the poison is so deadly I look upon it as almost a miracle that no man has been accidentally killed during the process.

Fig. 6.



Section of Portable Lethal Chamber.

Lethal Death for Animals to be Used as Food.

It will be observed that hitherto I have dwelt only on the process of lethal death in its application to small domestic animals, such as dogs, cats, and birds. I am expected to add something more in reference to the painless destruction of those animals which supply us with food; but as the Society over which I have the honour to preside, the "London Model Abbatoir Society," is about to build a model slaughterhouse, in which painless killing will form an important feature, it would be premature to enter into any details, until by careful trial the best methods have been secured. I may, nevertheless, be permitted to indicate that in respect to certain animals the painless death is quite feasible. By means of carbonic oxide, sheep can be put to sleep with the greatest rapidity before they are slaughtered. I have submitted forty sheep in this way to painless death, and found that no bad effect whatever is produced in the flesh unfitting it for food. The objection to retention of blood, so strongly felt by the Jewish people, does not obtain, the animals in the narcotic state yielding up blood just as freely as if the ordinary way, when no narcotic is used. The same process is equally applicable to swine, calves, and fowls. To oxen I do not as yet see its immediate application.

Comparison with other Modes.

I have several times been asked whether there is any other method for the painless killing of animals intended for food which might be considered by the side of the lethal method. There is only one other mode which is really worthy of consideration, and that is the mode by the electric shock. The electric shock for this purpose was first proposed by the illustrious Benjamin Franklin, some twenty years after he had proved, by the famous kite experiment, the identity of the electrical and the lightning discharge. His suggestion is supplied in a letter, which he wrote, in 1773, to MM. Dubourg and D'Alibard, in the following terms :—

"Having prepared a battery of six large glass jars (each from twenty to twenty-four pints), as for the Leyden experiment, and having established a communication, as usual, from the interior surface of each with the prime conductor, and having given them a full charge (which, with a good machine, may be executed in a few minutes, and may be estimated by an electrometer), a chain which communicates with the exterior of the jars must be wrapped round the thighs of the fowl; after which, the operator, holding it by the wings, turned back and made to touch behind, must raise it so high that the head may receive the first shock from the prime conductor. The animal dies instantly. Let the head be immediately cut off to make it bleed, when it may be plucked and dressed immediately. This quantity of electricity is supposed sufficient for a turkey of ten pounds weight, and perhaps for a lamb. Experience alone will inform us of the requisite proportions for animals of different forms and ages. Probably not less will be required to render a small bird, which is very old, tender, than for a larger one which is young. It is easy to furnish the requisite quantity of electricity, by employing a greater or less number of jars. As six jars, however, discharged at once, are capable of giving a very violent shock, the operator must be very circumspect, lest he should happen to make the experiment on his own flesh, instead of that of the fowl."

In pursuit of Franklin's idea, Mr. Collinson, an Englishman, a friend of his, endeavoured to carry out the method in practice, in which attempt he himself received a shock, which told him that electricity was no respecter of animals. The experience put an end to the proposed method until the year 1869, when I revived it by means of the large induction coil then fitted up at the Royal Polytechnic Institution. I used in these inquiries twelve large Leyden jars, the whole representing ninety-six square feet of surface. In some cases the discharge was made in the ordinary direct way, in other instances the jars were set out in cascade, on the plan devised by Benjamin Franklin. The results, as many who saw them will remember, were most striking. It was proved that the shock in cascade was the most fatal, but by both methods small animals, rabbits and birds, were killed so instantaneously that they actually remained in the exact position they had assumed at the moment the shock was given, so that it required careful examination to prove that they were really dead. In these small animals the bodies were left after the shock in a state of complete rigidity; but in a short time the rigidity subsided, and the flesh ate tender. The common idea that after death from electrical shock rapid decomposition ensues was disproved, for in all cases the bodies of the animals remained for several days free from decomposition. In another series of experiments, larger animals, sheep, were subjected to the shock, and in every instance unconsciousness immediately followed the application of the shock, the current being passed from the heads of the animals through the body to the hind extremities. The method proved very difficult to carry out in practice, for two reasons. Firstly, it was found that if the shock were so decisive that death took place absolutely, the animal would not afterwards bleed, while, if the shock were not completely decisive, the animal, during the flow of blood, evinced certain signs of returning consciousness, a phenomenon as remarkable as it was unexpected. Secondly, it was found, as in Mr. Collinson's experiments, that the administration of the shock would be dangerous to the operators, unless they took more care than could be expected from the men who are employed in the duties of the slaughter-house.

I do not despair altogether of making electricity practically useful for the extinction of life of some of the larger animals, such as horses and oxen. I have in view the construction of a porch through which a large animal may be conveyed on a truck, and during the passage through which and in no other position may receive the fatal shock. But at present the expense connected with the carrying out of this suggestion would in itself be a barrier to success.

Concluding Note on Expenditure connected with the Lethal Process.

The use of the word expense leads me, finally, to refer to a question which has been

asked of me from various parts of the kingdom, relative to the expense of setting up the lethal apparatus.

In what has been done up to the present time, so much has, of necessity, been experimental, it would not be fair to calculate the expenditure connected with these first efforts as a guide to what would be the cost of a new apparatus made from the completed design. Roundly, I may say that the prime cost of the large chamber and cage, for material and labour exclusively, was, in the first instance, about £145. Since then, another cage and another stove have been added, together with iron lines, new being fitted, and with various alterations which have increased the expense. I think, however, that such a chamber, starting afresh, with all the details now understood, could be constructed for, from £150, to £175. The smaller chamber has cost, in the original working out, a larger sum in proportion, owing to the difficulties of adapting it to all requirements demanded, and the frequent reconstructions. Now, however, that it is brought into practical form, a new design from it may, I think, be constructed for £50, and if there were a demand, for even less.

The cost of charcoal for the stoves with the addition of anæsthetic fluid is, in the large chamber, a little over one halfpenny per animal when eighty to a hundred are killed at one time. When fewer are killed the expense is a little increased; the trouble and substance required being as little for a hundred as for a less part of that number.

The cost of working the little chamber is not so easily reckoned, inasmuch as the labour for moving it from one place to another will vary, while the anæsthetic required for destroying one animal would be nearly the same as for six or eight introduced at once. In any place where the small chamber is retained as a fixture, and where it is kept carefully closed, it will at all times be charged with anæsthetic vapour, and be very little more expense than the larger apparatus.

I bring my lecture to a close with the reflection that science, sometimes considered hard and unrelenting, has in this case another and different feature. If she sometimes, for the sake of man, inflicts pain on the lower creation, here she relents and does for the lower creation what she dare not do for man. By comparison, the boon is enormous. Except for the corporeal suffering, the dumb animal seems to have no pain in the prospect of death, while to man, "The sense of death is most in apprehension," and to most men is so even more acutely than the act itself. Thus he who wrote the burial service expressed the most universal of desires that at our last hour no pains of death may fall. Perchance for himself and his own kin, man, with all his ingenuity, will never see his way to escape that desire, until by a better life he wins the death by natural sleep, which nature has ordained to be as painless as his birth. Grateful, nevertheless, may he be that the power is in his hands of giving to his inferior earth-mates what he himself most earnestly prays for, Euthanasia.

The CHAIRMAN (Mr. Edwin Chadwick, C.B.) said their thanks were due to Dr. Richardson for his excellent exposition, but beyond that, for his great invention. That invention formed a large addition to the other inventions connected with the surgical and curative art which surgeons and physicians had acknowledged some years since by a large testimonial among themselves, since which time Dr. Richardson had, by his invention, largely advanced the means of diagnosis. He (Mr. Chadwick) hoped he might be pardoned for regarding the invention as a valuable addition to the beneficent functions of the police service. Up to 1838 almost the only police force were the night watchmen. He, at that time, wrote a paper to shew the expediency of superseding these inferior forces by one superior force under unity. It was the only exposition of the principle of which he was aware, and it certainly led to its adoption. Besides, the service for the repression of crime, their functions were extending for the protection of the population against accidents and calamities. They had charge of more than three thousand of people who were wounded by accidents in the streets annually, and their conveyance to the hospitals or their homes. They gave their services to the guidance of between three and four thousand bewildered and lost men, chiefly foreigners. Then fell to their care the restoration of between eight and nine thousand bewildered and lost children; they had, moreover, the care of more than twenty-two thousand bewildered and lost dogs. Those creatures who had the strongest sympathies for mankind deserved sympathy from us; and it would create a satisfactory impression from the paper read to-night, that those creatures for whom no owners could be found would, after a time, under the care of the police, receive a painless termination to their existence. Let it be known that the cost of all these and much more of annual services, such as the regulation of fourteen thousand vehicles, and the regulation of common lodging-houses, is about a penny a week per house. As a commissioner of inquiry into the organisation of police forces, he had watched the

progress of such beneficent services, and he hoped that he might be pardoned for adverting to them, and expressing pleasure at the addition Dr. Richardson had made to them.

Mr. Colam seconded the vote of thanks to Dr. Richardson, and also expressed the special thanks of the Committee of the Dogs' Home for his invention, which was of the greatest value to their institution.

Correspondence.

SMOKE ABATEMENT.

Your correspondent, Mr. Wilkinson, appears to write as if the system of boiler setting, adopted by me, is one I have some interest in commercially. I have no interest whatever in it commercially. My boiler was erected as an experiment, the system of setting has been copied by many, and it is at any time open to inspection and to be copied. I note in *Iron*, December 5th, a description of a "blowpipe flame furnace," in which a similar principle of setting is adopted, *i.e.*, a shallow flue the same section as the boiler, and a mass of brickwork at a high temperature, over which the products of combustion pass after they leave the fire.

Thos. Fletcher.

December 22nd, 1884.

SANITATION IN JAPAN.

I have read with much interest the communications of your correspondents, Mr. Brunton and Mr. Cawley, on "Sanitation in Japan." That practice has not rapidly followed theoretical advance in knowledge, is, I suppose, a reproach to which western not less than eastern nations are alike subject in this matter. As to the marvellous strides made by the Japanese in the course of a very few years, of the transformation of a strictly feudal system, and close Chinese practice, into the open study and diffusion of European knowledge, I suppose there can be no question. I have before me the reports of the Sanitary Board, and the special reports of the Japanese Commissioners, on the subjects of sanitary organisation; study and prevention of epidemic diseases, dietetic values, &c. They are all from Japanese hands, and testify to an enlightment, an accurate and deep study, and a mastery of European methods and principles, which to anyone who knows how recently Japan entered the sphere of modern civilisation, is perhaps the most interesting and striking ethnical phenomenon which has ever presented itself to notice. The courtesy, the intelligence, the painstaking research, the accuracy and extent of investigation seen in these reports are exemplified and reflected in the many Japanese whom I have met in Europe on Government missions, or in course of education; and among whom I count many friends. The most intelligent travellers in Japan have spoken to me in similar terms of their personal experience. I rejoice to know that the International Health Exhibition has been utilised by the Japanese Commissioners more seriously, and on a larger and more practical scale than could have at all been anticipated, and more than by the Commissioners of any other nation. We may all trust that they will soon benefit as much in their individual homes, as they certainly have in their public organisations, by the knowledge so eagerly sought from English sources. At the present moment, the Commissioners are busy visiting our prisons, and hospitals, and studying their sanitary arrangements with intelligent care.

Ernest Hart.

38, Wimpole-street, W.
December 20, 1884.

General Notes.

Proposed Exhibition at Trautenau.—According to the German press, an Exhibition of commerce, industry, electricity, agriculture, and forestry, will be held in 1886 at Trautenau, the political centre of the Riesengebirge district. It is expected that the support of the various branches included in the scheme will make the enterprise a success.

Lumber Trade of the United States.—According to an American journal, the lumber industry will, in all probability, in the course of ten years or so, be transferred from the northern lake region to the south. Some idea of the enormous extent of the industry may be gathered from the following figures. In 1880, there were 25,708 lumbering establishments in the country, employing capital to the extent of $181,000,000, and 146,000 hands, distributing $31,845,000 per annum in wages, using $146,000,000 worth of material, and turning out an annual product of $233,000,000. Michigan ranks first, with a product of $52,449,000; then comes Pennsylvania, with $22,457,000; and then Wisconsin, with $17,952,000; New York, with $14,160,000; Ohio, with 13,864,000; Minnesota, with $7,366,000; and Main, with $7,900,000. Very few of the Southern States reached a product of over $4,000,000; but on the other hand, Michigan is consuming its lumber at a fearful rate. The magnificent pineries of Michigan and other States in the lake region are fast disappearing before the axe, and are being sawn into boards for building farmhouses and towns in the prairie regions of the West. But the whole South is a forest region, and when the Northern lumber supply fails, the great sawmills will be removed to the Southern forests, and these will become the new centres of the industry.

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FRIDAY, JANUARY 2, 1885.

All communications for the Society should be addressed to Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

Mr. J. Norman Lockyer, F.R.S., delivered the first of his course of lectures on "Universal Time: our Future Clocks and Watches," on Wednesday evening, December 31st. He illustrated the action of clocks and watches, and described the mode of dividing time, from the first arrangement of unequal hours to the new astronomical calculation of the twenty-four hours from midnight, which was to be put into effect from that very night. He then showed how it was possible to prove that the earth, the sun, the moon, and the stars are round. By magnetising a ball, and covering it with tacks, he illustrated the attraction of the earth by reason of which the inhabitants do not fall off, and concluded by setting in motion a pendulum suspended from the roof, to show the rotation of the earth in accordance with Foucault's experiments.

The second lecture will be delivered on Wednesday evening next, at seven p.m.

Proceedings of the Society.

CANTOR LECTURES.

ON THE USE OF COAL GAS.

By Harold Dixon, M.A.

Lecture II.—Delivered December 8th, 1884.

When last I had the privilege of addressing you, I mentioned that the diffusion of lighter gas into denser air through a porous diaphragm might be made use of for determining whether there was an escape of gas in a room; that the lighter gas, passing more quickly through a porous diaphragm than the heavier air got out, would increase the pressure inside the vessel, push down a column of mercury, make metallic contact with a battery, and ring a bell. Since last week I have received one or two letters on this subject, and, thinking it might be of interest, I have put up a rough apparatus, to illustrate how such an instrument as I have described might be made. Instead of having a straight arm, in which a coloured liquid, such as a solution of indigo, is moved, I have connected with the porous vessel a bent U tube, with mercury in the bend. There is a platinum wire sealed through the glass tube, which I can connect with the wire from a battery; a wire also passes down the open end of the tube, and may be placed at any suitable distance from the top of the column of mercury. If I connect up, and let a little coal gas escape close to the porous pot, the gas immediately diffuses through the pot more quickly than the air can get out; the pressure is increased inside, the mercury is pushed down in the arm connected with the vessel, is pushed up in the other arm, and metallic contact is made between the mercury and the platinum wire. Immediately the battery circuit is completed, a bell at the other end of the room announces the escape of coal gas from this pipe.

I pass on now to the subject proper of my lecture this evening—the use of coal gas as an illuminating agent. We saw last time that, of the components of coal gas, only a small part, by volume, contributes to the light, that the carbonic oxide, hydrogen and marsh gas, which made up some 95 to 97 per cent. of the whole, contribute barely anything to the light given by the gas flame; that the other constituents, the ethylene, or olefiant gas, and the other gases of the same type as ethylene (the olefines), and the benzene and the naphthalene, are the gases whose burning gives light in the flame. Now, the light is due to what may be not inaptly called a selective combustion. When coal gas is burnt in air, and care is taken that the gas does not mix too quickly with the air, but comes into it gradually, the hydrogen of the hydro-carbons burns before the carbon. Let us take ethylene as representing the luminiferous constituents of coal gas; each molecule of ethylene is composed of two atoms of carbon and four of hydrogen, and chemists write it $C_2 H_4$. This ethylene, when

it is raised to a high temperature in contact with air, is decomposed, the hydrogen burning first and the carbon afterwards. There is a race for the oxygen of the air between the two constituents of the ethylene, and the hydrogen, being the fleeter of the two, gets to the oxygen first, and is burnt to water. So for a short time the carbon of the ethylene is unburnt, and is separated from the hydrogen. It aggregates into little solid particles, which are raised to incandescence by the burning gases around. The carbon then, in its turn, reaches the air outside the flame, and burns to carbonic acid. If we wish, then, to get light from coal gas, we must burn it in such a manner that the hydrogen burns first and the carbon afterwards.

Before I go on to show the particular burners which have been devised by many skilful hands to gain this object—the selective combustion of the hydrogen before the carbon—I will burn a sample of coal gas which has been deprived of the luminiferous hydro-carbons by treating it with Nordhausen acid; and to compare with that I will take some ordinary coal-gas, and burn it in a similar vessel. In these two vessels, then, I have a sample of coal gas which has been treated with Nordhausen acid (and so deprived of the luminiferous hydro-carbons), and a sample of ordinary coal gas. When I burn them, you see the difference in illuminating power is very well marked. In one case you have a flame with more or less light in it, due to the separation of carbon; in the other you get no light at all. In the latter case, the coal gas has been deprived of the three or four per cent. of ethylene and luminiferous hydro-carbons by the Nordhausen acid. I will try another experiment with ethylene, to show you an example of selective combustion. With this ethylene I will fill this glass cylinder one-third full. I will now take another gas, chlorine, and fill up the cylinder with it, so that in this way I get a mixture of two volumes of chlorine and one of ethylene. Now, I apply a light. I ask you to look at this deposit of carbon. The mixture of ethylene and chlorine is perfectly transparent; but as the flame ran down the cylinder the chlorine effected a selective combustion. It took the hydrogen only and left the carbon. The carbon is left in this finely divided state, and the whole of this cylinder is now filled with this fine smoke—little solid particles of carbon—because the carbon has not the same affinity for chlorine that hydrogen has.

A selective combustion, similar to this, but not selective in so marked a degree, is shown when coal gas is burnt in air. The hydrogen has a stronger affinity for, and is quicker in burning with the oxygen of the air than the carbon is. The latter gets left behind, just as it was left behind in burning with chlorine, only there is this difference that in the case of the chlorine the carbon was not burnt at all, but was all left behind, whereas, in the case of ethylene burning in air, or coal gas burning in air, the carbon is finally all burnt.

Through a bye-pass in this lamp I am now passing some ordinary coal gas. It burns with a luminous flame, giving a light, perhaps, of some seven or eight candles, certainly not more. You notice that if I turn on the gas too full, we get this roaring of the gas-flame, of which I shall have to speak more fully directly, but I now turn it down, so that it no longer roars or flares. The flow of gas can be turned through the body of the lamp, where it passes over some condensable hydro-carbons, and then you see the gas mixed with these hydro-carbons gives us a very much whiter flame than ordinary coal gas. This lamp illustrates the effect which these hydro-carbons have on the illuminating power. Now, since it is entirely due to the small quantity of ethylene and other hydro-carbons that we get light from coal gas, their proportion is, of course, a matter of great importance. Anything in the process of the gas manufacture which will add to the volume of ethylene and other hydro-carbons, will increase the value of the gas; and the best way of determining the value of a sample of coal gas is to determine the volume of the olefines which it contains.

This lamp will also illustrate another point, and that is the effect of pressure on the burning of coal gas. You see if I turn the tap on full, there is now such pressure at the burner that we get this roaring flame, and very little light from it; not nearly so much light, you will notice, although the flame is longer, that there is when I turn the gas down and burn less. We get a better light with a steadier flame than we do when it is roaring. Now, I will turn the tap down, and regulate the gas supply until it burns with a quiet flame; then, by quickly turning this tap round, I can make the gas pass over the hydro-carbons. The gas will then become mixed with some of the hydro-carbon vapour, and you will see that, although it is burning under the same pressure, it will no longer burn with a quiet flame. Turning off the gas from the hydro-carbons, there is a quiet flame with the

same pressure of gas. It is evident, then, that coal gas must be burnt with due regard to pressure; a rich gas must be burnt with less pressure than a poor gas, to give a steady light.

Now, pressure chiefly acts in this way. With a high pressure the gas is forced out quickly from the small orifice of the burner, and so mixes with the atmosphere before it burns. But there is also another thing. When gas issues quickly from an orifice, it forms what we may call whirlpools of gas, and burns irregularly on this account. I do not know why, and I do not think any one has yet explained, why coal gas which has passed round a corner suddenly like the corner of a gas tap near to the burner, should burn with an unsteady flame some six or eight inches off, but such is the fact. The coal gas in passing round the corner suddenly seems to be thrown into eddies, and it is a long time before it steadies down to a regular flow. Why it should be so long, I am quite in ignorance, but there is the fact; so that, if you have a tap close to the burner, and the pressure is too high, and you try to reduce the pressure by turning down the tap, you will very often get such an eddy produced, and a flickering flame is the consequence; so I recommend, in all gas burners in a room, that the tap should be placed some two or three feet off the burner. In that case, in spite of the gas running past the sharp edge of the tap, it has time to steady itself down into its normal flow, and burn with a steady flame.

I have here an ordinary gas burner—a fish tail—and I have connected it with a bag containing coal gas. By suitable pressure on the bag, we can drive out the gas at any rate we please. I am increasing the pressure now, but however much one increases the pressure, even to making the gas roar, one does not increase the light one gets from it. The gas is forced out into the air and mixes with it, the rush of gas produces a partial vacuum in the immediate neighbourhood of the orifice, the air is drawn in and mixes with the gas, and the two burn together with this blue, almost non-luminous, flame. Here is another burner, connected to the same supply pipe. In the one case, we have the gas pouring straight out into the atmosphere, unchecked in its flow. In the second case, we have a governor placed between the gas pipe and the orifice where the gas issues into the air. This governor checks the flow of the coal gas, and only allows a certain quantity to pass. The effect is, that the flow is regulated and maintained at that rate which is found to give the best light for the particular sample of coal gas used. While one flame roars and gives but little light, the other continues to burn steadily and well. Now, unfortunately, in all gas supplies on a large scale, one cannot get rid of inequalities of pressure. Some houses are on higher ground than others, and of course, owing to the lightness of coal gas, they have an excess of pressure. Again, when large quantities of coal gas are being consumed, as in the evening hours, the pressure has to be turned on in the gas-works, and sometimes—until the consumption reaches its maximum—there is an excess of pressure in the mains. Now, with a governor such as I have shown you here, this roaring and wasting of the gas is completely got rid of. I will not go so far as to say that every burner in a house must necessarily have a governor, but I think a governor should be placed on each floor, which will regulate the flow of gas to all the burners on that floor. But the burners with which one is more particularly concerned, those in our sitting-rooms and dining-rooms, should each have their separate governor. By this means one gets a steadier flame, and one burns the gas to more advantage.

We may say, then, that the first requisite for obtaining a good artificial light from coal gas is that the flow of gas into the air should be regular and as slow as possible. Several contrivances have been elaborated to produce this result. Some are complicated, and some apparently quite simple, and I may say that the simple ones seem to me to work nearly as well as the more complicated. Here are two different kinds. In the one, there is a large chamber introduced into the burner below the orifice; into this chamber the gas passes through a small hole. The hole being smaller than the orifice through which the gas finally escapes, the gas rushes through the small hole into the chamber, and then passes slowly out through the orifice. The other plan is to have a moveable diaphragm just below the burner, which is pushed up by the pressure of the gas. Whenever the pressure of the gas below this diaphragm is greater than the pressure above, by the weight of the diaphragm, it moves up, and partially closes the orifice through which the gas escapes. Such is the form of governor used in Mr. Sugg's burners. A piece of steatite is pushed up by the gas, and partially blocks the hole from which the gas escapes

into a chamber below the burner; so that, if the gas is running in under a greater pressure, the diaphragm is pushed higher up than when the gas is running in under a smaller pressure; consequently, with the greater pressure, the hole through which the gas can escape to the orifice is smaller than in the other case, so that the same quantity passes to the burner, whatever pressure is used. I have not time to describe all the various forms of governors that have been devised for limiting the flow of gas; I merely describe these two types, for all others depend, I think, upon the same principles—either the filling of a large chamber through a small hole, or else the movement of some diaphragm which checks the passage through which the gas is flowing, like the throttle-valve of a steam engine.

Now, the second requisite for obtaining a good light from coal-gas is that the supply of air should be steady, regular, and slow to the gas flame. We have seen that it is necessary to have the supply of gas steady and slow, and we find the same thing is true of the supply of air.

Now, with a flat-flame burner in the air without a chimney, it is not easy to get the supply of air regular. One of the devices which have been adopted with very considerable success, I think, is to make a little projecting ridge all along the top of the burner. Mr. Sugg calls this the table-top burner. This ridge prevents the air which is rising to feed the flame from impinging too directly on the flow; it is spread out a little by this ridge, and so meets the flame a little further up. Another successful device is due to Mr. George Bray. Mr. Bray has checked the flow of air in the flame. He has placed a metal shoulder on each side of the burner, and the air is thus prevented from coming in contact with the edge of the flame for some considerable distance, about an inch, on each side of the central orifice. I light this burner, and you notice how the flame hugs the shoulder where the air is prevented from impinging against it by this metallic projection. in this way a very broad flame is obtained. The difference in illuminating power between these two—the "table-top" and the "shoulder" burner—is, I think, inappreciable. In the few experiments I have made on their illuminating power, I found this burner of Mr. Sugg's to give slightly the better duty, but the difference was so small as hardly to be appreciable. The shoulder gives a little broader flame, and the other, I think, a little intenser light. Each of these gas lamps consists of a cluster of three burners, and in these clusters we have another principle coming into play—first recognised, I believe, by Mr. Bray—the augmentation of the heat of one flame by the heat of others. If we have one flame burning in the vicinity of another, the two will give out more light together than they do independently apart. The sum of the two lights is increased when they are burning close together. That is owing, first of all, to the air which passes up between the flames being heated by radiation; and, secondly, the gas itself is heated by radiation from the other flame. To put it in another way, which really comes to the same thing, the radiation from one flame is stopped by the other flame, and, therefore, each is hotter. Now these flat-flame burners have been very much improved in the last few years, so much so that there is not much difference now between the light which can be obtained from them and from the Argand burners, where the gas is burnt in a round ring under a chimney. There is one point about these flat-flame burners which I should like to call your attention to, for I do not know that it has been studied particularly by photometrists, that is the transparency of a gas flame to the light of another gas flame. In an Argand burner we have a ring of flame, so that the light from the further portion of the flame has to come through the nearer portion before it reaches us. Now it is certain that there is some loss here, but I do not know that there has been any accurate experiment made as to the loss which light suffers by going through a gas flame. I have come across one or two determinations of the illuminating power of such a flat flame as I have burning on the table, first taken from the flat side, and secondly taken edgeways. The difference in illuminating power is found to be considerable. I have some figures here of experiments which Mr. Harcourt made about a year and a-half ago. He found that the light from a flat-flame burner was about 33 per cent. less when it was put edgeways. That is to say, if you call the light given from a flat flame 100, he got about 67 for the light coming from the edge of the flame. The flame is evidently not transparent. But I was surprised to find that the transparency is so small as it is. I made an experiment last week of this kind. An inch and a-half in front of a flat-flame burner I placed a metallic diaphragm with a slot in it. I measured the value of the gas flame seen

through the slot with Mr. Harcourt's pentane photometer. Next, I lit a second gas flame an inch and a half further off, that is to say, three inches from the slot, and I measured its illuminating power independently. I then lit the two together, and measured the light from the two. Now if the first flame had been perfectly transparent to the second flame, the light I should have received when burning both flames would have been equal to the sum of the two lights taken independently, but that was far from the case. In one experiment I found a loss of 24·7 per cent., and in the second case a loss of 25·4 per cent. So that we may take it that a flat flame of the thinness you see here obstructs the light from another flame to such an extent that only three-quarters of the light from the second flame gets through. The bearing of this on the relative merits of the flat flame and the Argand is at once seen. In the Argand you depend greatly on the transparency of the flame, because a great part of the flame is hidden from you by the flame in front, whereas in the flat flame it is not so. The flame is spread out over a large surface, and the light only suffers absorption in the plane of the flame.

There is another burner, also a flat-flame burner, surrounded by a globe, about which I have a few words to say. I think coal gas as an illuminant would be much more popular with English people if the makers of the globes which are commonly sold had been persuaded, or could be persuaded, to make the openings through which the air enters just about double as large as they have made them. One is accustomed to see in one's friends houses, almost without exception, a globe with an opening as small as $2\frac{3}{4}$ inches. Openings of 2 inches are quite common, and I have seen them as small as $1\frac{3}{4}$ inches. Now, what is the effect of such a globe with so small an opening, on the burning of gas? The air comes in with a rush to the flame, and is thrown into eddies, in pouring through such a narrow orifice. Consequently the flame is thrown first on one side, and then on the other, and it is in a continual state of flickering, always on the quiver, never still for half a second. It is this continual flickering when one is reading that is the chief objection to coal gas as an illuminant, as we find it in most houses. The flickering is entirely got rid of if you only have the opening big enough. Here is a burner on the table supplied with a governor, and with a globe with a large opening, $3\frac{3}{4}$ inches, nearly four inches across, so that the air can pass into the flame with a steady flow; it is not thrown into eddies, and does not agitate the gas. Such a burner as this does not burn any more gas than a burner surrounded by the globe with a small opening

If we want to get the best light possible from the consumption of a certain quantity of coal gas, the way to do it is to burn it in a lamp with a chimney provided with a damper, for by this means we can regulate the supply of air to the flame so as to give it just that quantity which burns the flame with the maximum quantity of light. Now the maximum light is given just below the point at which the flame begins to tail up and smoke. One should stop just short of that, and the way to do it is this: —Turn on your gas and get your supply, five feet per hour, or whatever the burner is constructed for, and then turn down the air until the flame just does not smoke. In that way you get the best light from a coal gas flame.

I have here what is known as the London Argand burner; it has a ring of steatite, pierced with a number of holes, through which the gas comes in little jets, which very soon coalesce into a bright ring. Then, surrounding this ring, placed a little lower than the burner, is a metal cone, which causes the air passing in at the bottom of the burner to inpinge upon the flame. On the same stand I have another burner, in which this Argand principle, if I may call it so, is further developed. There are two rings, through which the gas is burned, one inside the other, and the air passes up between the two. We have, in fact, a double Argand. The chimney has a shoulder which compresses the two annular flames. This burner requires to burn some little time before it gives a steady flame, but when it has been burning for some ten minutes, it gives an exceedingly intense light, especially in the lower portion of the flame. I will leave this burning, so as to get warm. The London Argand does not require any manipulation. Sir James Douglass's double Argand requires to be burned some little time before it developes its maximum quality of light, and the flame should be turned up after it has been burning a little while.

Mr. Sugg has also made Argands with more than one ring. Here I have a very fine burner with two rings and a straight chimney. You notice the chief difference between the two burners is this. Whereas Sir James Douglass has placed a conical chimney over the flame, so as to throw the air against the outside of the flame, and so compress it, in Mr. Sugg's

burner the chimney is straight. It gives a very large steady flame, but I think, on the whole, it is not so intense and white a flame as one gets from the burners of Sir James Douglass. There are, of course, many varieties of Argand burners. I could not show you all; I have only taken such as appeared to me to be the most characteristic and, I may add, among the best that are made.

Of regenerative burners, I propose to show you one—that of Mr. Bower. It is, I believe, an improvement on the Grimston burner with which I was acquainted some few years ago. By the kindness of Mr. Bower, I have this lamp suspended here in the corner of the room. The lamp is what is known as a reversed regenerator, that is to say, the flame is at the bottom; the products of combustion pass up through a series of iron chambers, and pass away through a pipe, and the air which feeds the lamp is drawn down past the iron chambers, through which the products of combustion are passing away, and therefore is strongly heated up before it reaches the flame. The iron chambers above the flame, when it is turned up, become red hot. Below the lamp is placed a glass shade, to prevent the outer air reaching the flame; but Mr. Bower has found that the lamp is improved by allowing a little air to enter. He accordingly has an adjustable valve by which air can be admitted to the flame—there is a screw by which the quantity of air so entering can be regulated—and this air impinges on the lower surface of the flame. The hot air passing down through the regenerators, strikes on the upper surface of the flame, whilst the cold air only strikes on the under surface. The reason for this arrangement is, I believe, that in the old Grimston burner, where no cold air came in, the glass shade underneath got exceedingly hot, and always got dimmed, as if a deposit formed upon it. Perhaps this was owing to the glass becoming partially devitrified. But with this system of admitting a little cold air, Mr. Bower tells me the dimming does not occur. I have not yet had an opportunity of experimenting with this the latest form of the Grimston lamp, but I am assured that it gives a duty, that is to say, an illumination per cubic foot of gas burned, of something like seven or eight candles; if so, I can only say it is a most marvellous lamp, and I look forward with great interest to measuring it photometrically.*

About the relative merits of coal gas, oil, and electricity, as illuminants, I do not propose to speak to you this evening; I am only concerned with coal gas itself; but I have written up on the black board a few statistics concerning the cost of artificial illumination, for which I must apologise if they are out of date. In the first column are the names of the illuminants; in the second column the price per lb., per gallon, or per 1,000 cubic feet of the illuminating material; and in the third column the cost per hour of lighting a room of moderate size well, that is, giving it an illumination of twenty-five candles. The table was drawn up from the results of photometric experiments by Mr. Vernon Harcourt.

	Per lb.		Cost per hour.
Spermaceti candles........	—	..	$9\frac{1}{2}$d.
Stearine	—	..	$4\frac{1}{2}$d.
Sherwood wax............	—	..	$2\frac{1}{2}$d.
	Per gall.		
Alexandria oil............	1s. 10d.	..	$\frac{1}{2}$d.
Colza oil (in moderator lamp)	4s. 0d.	..	$1\frac{3}{4}$d.
	Per 1000.		
Flat flame gas burner......	—	..	$\frac{1}{3}$d.
Large Argand ,, ...	—	..	$\frac{1}{4}$d.
Siemens' regenerative burner	—	..	$\frac{1}{5}$d.

I will now show you a still more brilliant gas-burner at the other side of the room. One purpose for which a very brilliant light is required is for the beacons on our coast, which warn sailors when they are approaching the shore, and guide them through the tortuous channels round our island. Of these burners, those invented by the engineer of the Trinity House—Sir James Douglass and those of Mr. J. R. Wigham, of Dublin—rank in the first class. This burner of Sir James Douglass is burning ordinary coal gas here, but it was devised to burn a richer cannel gas. In it the Argand principle has been repeated six times; we have six rings of flame, one outside the other. Each ring has a separate tap, by which the flow of gas to it may be regulated, and it has the same cone-shaped chimney which Sir James Douglass adopted in the smaller Argand on the table. Owing to the shoulder in the chimney, the air is thrown against the flame, and we get a very much

* Since this lecture was delivered, I have tested the 25 feet Bower lamp by Mr. Harcourt's pentane photometer. The light given by the burner is a horizontal plane, burning 27·1 (corr.) cubic feet of 16·5 candle gas per hour, was equal to 182 candles. This is equal to 6·7 candles per cubic foot, or 6·5 candles per cubic foot of 16 candle gas. The cost of obtaining an illumination of 25 candles from this burner, burning 16 candle gas, would be $\frac{1}{7}$d. per hour. I must add that below the horizontal plane the intensity of the light increases.

intenser light than we otherwise should; and not only that—and this is the point of greatest importance—we get the flame contracted into a smaller body than we otherwise should get it. This inrush of air all round pushes the flame together. I think the actual contraction makes the flame brighter, but when such a flame is placed behind a lens, the nearer you can bring all the light to one focus, the more truly can you send out the refracted rays parallel, and therefore, the less scattered the beam from the lantern will be. The smaller the flame the better the result with the lens, and this is the reason, I think, why these burners are so successful when shown in a lighthouse lantern. The particular thing to notice about this burner, is the exceedingly bright zone of light about one inch above the metal base. This zone is placed in the focal plane of the lantern, and the light from it is most accurately focussed by the lens, and the refracted rays sent out parallel. Using such a lamp as this in one of the experimental towers on the South Foreland, and placing in front of it a lens six feet high by four feet broad, I found on a clear night, at the distance of about two miles, that the light received from it by a photometer disc was equal to the light from over 90,000 candles, the burner consuming only ninety-six or ninety-seven cubic feet of cannel gas per hour.

Speaking of the experiments at the South Foreland naturally leads me to one other topic, not perhaps directly connected with the subject, but one on which those interested in gas manufacture will perhaps forgive me for saying a few words—that is, the standard of light to be used in testing gas flames. Two or three standards of light have been devised, and one has successfully stood the ordeal of trial. I refer to the pentane standard of Mr. Vernon Harcourt. But one objection has been urged against this standard which neither Mr. Harcourt nor others who have experimented on the subject have been able fully to meet. There is a doubt whether the light produced by the pentane flame, two-and-a-half inches high, varies with the height of the barometer. It may be true that this has little concern for testers of coal gas, for the coal gas itself may suffer an exactly similar variation. As the coal gas goes up, so may the standard, and consequently the readings may be concordant one with the other under different conditions of atmospheric pressure. But when we come to consider a standard of light, such as is required in many physical experiments, it at once strikes us that a standard which may vary with the variations of atmospheric pressure cannot be an absolute standard. You all know that an absolute standard has been proposed in France, and, indeed, accepted by an international commission on standards, viz., the light given by a square centimetre of platinum at its melting point. I need hardly remind any of you who have worked with melted platinum, or seen it, what an exceedingly awkward standard this is. Not only is it exceedingly awkward to work, but as the platinum passes from the melting to the solid state, as it crystallises on the surface, the amount of light which it radiates varies very considerably. The platinum standard yields a constant light, I believe, for about the space of a minute and a-half. The only use of such a standard would be to standardise something more useful and portable. But I venture to think there may be another method of obtaining a constant light which may not be subject to variations of light with variations of pressure. I refer to an electric glow lamp with a very high resistance compared with the light that it gives out; connected with a battery, and some instrument for accurately measuring the strength of current flowing through the circuit. I have lately been experimenting with such a lamp in conjunction with Mr. Vernon Harcourt. In the experiments I have referred to at the South Foreland, where we have often to measure the light from the light-houses though an opening in the shutter of a hut exposed to the full south-west winds, we have found it exceedingly difficult at times to work with the pentane standard, and we have been anxious to devise another standard, which we could standardise first of all with the pentane, and then use. We have only lately had an apparatus of sufficient delicacy constructed, but as far as our experiments go, this standard promises to be of some use in future photometry, and I have brought it before you this evening, so that any one engaged in photometry may have an opportunity of examining it before it goes down to the South Foreland.

Here is a glow lamp of about ten ohms resistance, and it gives a light of about one candle with a current of one ampère. The life of such a lamp as that, I think, may be a long one; we may look forward to it out-living many of its brighter brethren, which give a light of from fifteen to fifty candles. This one is content with giving out only one candle light. Here I have a

simple form of rheostat, a wooden cylinder and a brass cylinder, on which a German silver wire may be wound from one to the other, so as to alter the resistance of the circuit. I pass the current, first of all, through this electro-dynamometer, which tells me the strength of the current. The current goes through a fixed coil of copper wire, and also through a moveable coil suspended inside the other. The moveable coil suffers attraction when the currents passes and turns round against the torsion of a wire. By a milled head at the top, I can put so much torsion into the wire as to bring the coil back to its original position of zero.

The method of working is this. The pentane flame is brought up to its normal height of $2\frac{1}{2}$ inches; the current is sent through the dynamometer, through the rheostat, and through the lamp; and the resistance of the rheostat is altered until the light is equal to that from the pentane. Then the reading of the scale is made. This gives the torsion in this wire, and the square root of that is proportional to the strength of the current. By turning the rheostat to the right or left, the amount of current flowing through can easily be regulated, and so the light adjusted to that of the pentane. Here are some of the readings taken last week. We were particularly anxious to take readings with a low barometer, and on two days last week the barometer fell to 29·3 inches. The following are four readings on different days:—

Barometer. inches.	Dynamometer scale.
29·3	1,204
29·5	1,212
29·6	1,225
29·7	1,238

You notice there is a regular increase in the scale readings with the rise of the barometer, but as yet we have only had this small range of four-tenths of an inch. Let me point out a very curious coincidence in these numbers. I said just now that the square root of the scale readings is proportional to the strength of the current. Let me take the square root of the two extreme readings. $\frac{\sqrt{1238}}{\sqrt{1204}}$ is $\frac{1014}{1000}$; that is, the strength of the current is 1·4 per cent. greater in one case than in the other. Now what is the difference between the two barometer readings? The ratio $\frac{29\cdot7}{29\cdot3}$ is also $\frac{1014}{1000}$, or a difference of 1·4 per cent. I do not wish to speak positively on this point, as there are several conditions which might affect the scale readings, such as changes in the torsion of the wire, or in the transparency of the glow lamp. Our experiments with the apparatus have only just began; but they seem to point to slight changes of light from the pentane flame with variations of the barometer, changes just perceptible with such an instrument as this, but totally inappreciable by any method of measuring light by a gas flame.

Next week I propose to consider those flames which have been used as a source of heat, and those which, by heating up a solid substance to incandescence, have been used as sources of light.

Miscellaneous.

ELECTRIC TRAM-CAR.

A tram-car fitted by Mr. A. Reckenzaun with secondary batteries and electro-motor, has now been running experimentally for some weeks at the works of the Electrical Power Storage Company at Millwall.

The car is an old one procured from one of the Metropolitan lines, and it has been drawn by horses between Greenwich and Westminster for many years. The body of this vehicle weighs $2\frac{1}{2}$ tons, and it accommodates forty-six passengers. The accumulators are of a special type manufactured by the Storage Company, from the designs of Mr. Reckenzaun. Placed under the seats on long trays, which run on rollers for their speedy removal, they are out of sight, and the whole car internally and externally has the ordinary appearance. The motor and gearing—Reckenzaun's patents—are placed underneath the car, and occupy so little space that to an ordinary observer they are invisible. The speed may be varied from three miles to ten miles per hour.

The accumulators weigh $1\frac{1}{4}$ ton, the motor, gearing, and accessories about $\frac{1}{2}$ ton, bringing the total weight of motive power to $1\frac{3}{4}$ ton for a car which, with its full complement of passengers, weighs itself $5\frac{1}{2}$ tons; whilst the batteries, motor, and gearing, are capable of furnishing at any desired moment a power of sixteen horses if required. This weight of motive power is compared with steam and compressed air locomotives weighing eight to ten tons, to do the same amount of useful work.

The line—4 ft. $8\frac{1}{2}$ in. gauge—is 400 ft. long, forming a right angle of nearly equal sides, so that about half way a curve of 35 ft. radius has to be passed. From one end, as far as the commencement of the curve, the road is tolerably level; but with this curve commences an incline of 1 in 40, which rises gradually until it reaches a maximum of 1 in 17 nearly at the

end of the up journey; thus it is impossible to make a rush for the hill on account of the sharp curve intervening.

The running cost, including 15 per cent. depreciation on machinery, and 50 per cent. on accumulators, is stated to be 3·5d. per car-mile, or about one-half of the cost of horsing on tram lines. The car on the line at Millwall runs for two hours with one charge, starting, stopping, and reversing every sixty seconds; and the accumulators can be replaced, it is said, almost as quickly as changing a pair of horses, by means of a trolly, which brings and removes the tray of cells, running on rollers. There are sixty of these accumulators, or thirty on each side. The load is distributed upon two small bogies, so that no objection may be raised on the part of tramway companies using light rails laid for horse-car traffic, and the old rolling stock can be utilised by putting the bogies which carry the motor under the car, and fitting the space under the seats for the reception of the accumulators. The car is lighted by four 20-candle power Swan lamps, and bell-pushes inside the vehicle enable the passengers to communicate with the conductor or driver by the ringing of electric bells.

Correspondence.

SMOKE-TESTING OF DRAINS.

When a sanitary engineer is called in to inspect and report upon a house, there are several tests, one or more of which he may use to, as a doctor would say, assist him in his diagnosis. He may plug up the drain and fill it with water, or attempt to do so; he may pour into it some strong-smelling volatile liquid, which will fill the drains and pipes in connection therewith with its vapour; or he may fill it with smoke which may be made as strong smelling as he pleases, and has the advantage of being perceptible by the eye as well as by the nose.

The engineer will select his test according to circumstances, but, it appears to me, that the smoke test will supersede all others for those houses to which it is applicable, and especially for the annual or periodic inspection of houses, which have been arranged upon correct principles, or put into a good sanitary state. It is much more easily and satisfactorily applied where there is a "disconnecting chamber" between the system of house drains and the sewer, or cesspool, and this forms an additional reason in favour of constructing such a "disconnecting chamber," which all sanitary engineers now recommend, but which householders sometimes omit on account of the cost.

The only objection to the smoke test for drains, hitherto, has been that it was troublesome and expensive to apply, chiefly owing to the weight of the apparatus used in applying it. It has been considered necessary to generate the smoke in an iron vessel on the surface of the ground, and from thence to pump it down by means of a centrifugal pump, or fan, into the drain to be tested. As both the generating vessel and the pump were heavy, the use of them involved the necessity of the engineer's going to and from the house to be tested, in a cab, and also taking an assistant with him to work the pump.

Acting upon a suggestion thrown out by my friend Mr. A. B. Brown, the eminent hydraulic engineer, of Edinburgh, that the smoke required might be generated inside the drain by means of a "rocket," I have lately devoted a good deal of time to designing cases of different shapes and sizes, and getting them made and filled with a suitable composition by Mr. James Pain, the well-known firework maker.

On Saturday, in Christmas week, several of the engineers of the London Sanitary Protection Association, and myself met Mr. Pain's representative at an unoccupied house in Kensington, to try a number of different sizes and shapes of "smoke rockets," and give Mr. Pain an order for the one which seemed most suitable.

The one fixed upon is 10 inches long, $2\frac{1}{4}$ inches in diameter, and with the composition "charged rather hard" so as to burn for ten minutes. This gives the engineer time to light the fuse, insert the rocket in the drain, insert a plug behind it, and walk through the house to see if the smoke escapes into it at any point, finishing on the roof, where he finds the smoke issuing in volumes from the ventilating pipes The house experimented upon on Saturday, had three ventilating pipes, and the smoke issued in dense masses from each of them, but did not escape anywhere into the house, showing that the pipes were sound. If the engineer wishes to increase the severity of the test, he throws a wet cloth over the top of the ventilating pipe, and so gets a slight pressure of smoke inside it.

The "smoke rocket" is not protected by any patent, and if any person wishing to try it writes to Mr. James Pain, 1, St. Mary Axe, E.C., for "Innes's Smoke Rocket," specifying the size, he will be supplied with any quantity.

The plug used with them is made by Mr. Francis Botting, of No. 6, Baker-street, and consists of two short frusta of cones put together small end to small end, with a central screw to draw them together, and a large rubber ring, such as one sometimes sees on the fetlocks of horses, round the circumference, so that screwing up the screw expands the ring, and unscrewing it allows it to contract. This plug answers for applying the water test to drains as well as for the smoke test.

I am happy to believe that the members of our Association who once have their houses put in order, or certified to be in order, by one of their own engineers, and afterwards have the drains and pipes tested periodically by burning "smoke rockets" in-

side them, run very little risk of suffering from the escape of sewer gas into their houses through their drains.

COSMO INNES, M.Inst.C.E.,
Secretary, London Sanitary Protection Association.
1, Adam-street, Adelphi, W.C.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

THE FOLLOWING DATES HAVE BEEN FIXED:—

JANUARY 14.—"The Employment of Hydraulic Machinery in Engineering Workshops." By RALPH H. TWEDDELL, M.Inst.C.E. Sir FREDERICK BRAMWELL, F.R.S., Pres.Inst.C.E., Vice-President of the Society, will preside.

JANUARY 21.—"Labour and Wages in the United States." By D. PIDGEON.

JANUARY 28.—"The Influence of Civilisation upon Eyesight." By R. BRUDENELL CARTER, F.R.C.S.

DATES TO BE HEREAFTER FIXED.

"The History and Manufacture of Playing Cards." By GEORGE CLULOW.

"The Musical Scales of Various Nations." By A. J. ELLIS, B.A., F.R.S.

"A Marine Laboratory as a means of Improving Sea Fisheries." By Prof. E. RAY LANKESTER, M.A., F.R.S.

"Recent Improvements in Coast Signals." By Sir J. N. DOUGLASS.

"The Evolution of Machines." By Prof. H. S. HELE SHAW.

"Education in Industrial Art." By CHARLES E. LELAND.

"The American Oil and Gas Fields." By Professor JAMES DEWAR, F.R.S.

"Past and Present Methods of Supplying Steam Boilers with Water." By W. D. SCOTT MONCRIEFF, M.Inst.C.E.

INDIAN SECTION.

Friday evenings at Eight o'clock.

JANUARY 23.—"The Agricultural Resources of India." By E. C. BUCK, Secretary of the Government of India in Revenue and Agricultural Department.

FEBRUARY 20.—"The Teak Forests of India and the East, and our British Imports of Teak." By P. L. SIMMONDS. Colonel MICHAEL, C.S.I., will preside.

MARCH 6.—"The Trade between India and the East Coast of Africa." By FREDERIC HOLMWOOD, British Consul at Zanzibar.

APRIL 17.—"The Parsis and the Trade of Western India." By JEHANGEER DOSABHOY FRAMJEE.

MAY 8.—"The Ancient and Modern Methods of Treating Epidemics of Small-pox in Japan." By ROBERT PRINGLE, late Sanitary Department H.M. Bengal Army.

MAY 15.—

FOREIGN AND COLONIAL SECTION.

Tuesday evenings at Eight o'clock.

JANUARY 27.—"With the British Association to the Canadian North-West." By STEPHEN BOURNE.

FEBRUARY 24.—"A New Route to Victoria Nyanza, through Equatorial Africa." By JOSEPH THOMSON.

The papers for the meetiugs of March 17, 31, April 28, and May 19, will be announced later on.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings at Eight o'clock.

FEBRUARY 12.—"Production of Ammonia from the Nitrogen of Minerals." By GEORGE BEILBY.

FEBRUARY 26.—"Tempered Glass." By Dr. FREDERICK SIEMENS.

The papers for the meetings of March 12, April 23, 30, and May 14, will be announced later on.

The dates given above are subject to alteration.

CANTOR LECTURES.

Monday Evenings at Eight o'clock.

The Second Course will be on "Climate, and its relation to Health." By G. V. POORE, M.D.

LECTURE I. Jan. 12.—The chief constituents of Climate, Latitude, Heat, Light, Barometric Pressure.

LECTURE II. Jan. 19.—The effects of Soil, Drainage, and Vegetation upon Climate.

LECTURE III. Jan. 26.—The chief sources of Atmospheric Impurities, both Inorganic and Organic. Climatic Diseases and Climatic Health Resorts.

HOWARD LECTURES.

Thursday evenings at Eight o'clock:—

The fourth lecture of the Special Course delivered under the Howard Trust, on "The Conversion of Heat into Useful Work, by W. ANDERSON, M.Inst.C.E., will be delivered on January 22; Lecture V. on January 29; and Lecture VI. on February 5.

ADMISSION TO MEETINGS.

Members have the right of attending all the Society's meetings and lectures. Special tickets are required for the Juvenile Lectures. Every member can admit *two* friends to the Ordinary and Lectural Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the members, but admission can also be obtained on the personal introduction of a member.

Journal of the Society of Arts.

No. 1,677. Vol. XXXIII.

FRIDAY, JANUARY 9, 1885.

All communications for the Society should be addressed to Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

On Wednesday evening, January 7th, Mr. J. Norman Lockyer, F.R.S., delivered the second of his course of lectures on "Universal Time: our Future Clocks and Watches." He described the mode of obtaining time, and showed the distinction between sidereal time and mean solar time. He then directed attention to the immense importance of true time for the purposes of navigation, and the confusion that was introduced into charts by the different meridians of the various countries, a confusion which the ancients had not experienced from their using one standard. In accordance with the new arrangement, Greenwich time would be adopted all over the world. Mr. Lockyer explained the resolutions of the Geodetical Congress, lately held at Washington, and expressed the opinion that in course of time our clocks and watches would all have twenty-four hours marked upon them instead of twelve. In conclusion, he explained some of the modes by which the dials might best be marked.

A cordial vote of thanks to the lecturer was carried unanimously, on the motion of the Chairman (Dr. Mann).

The first lecture is printed on page 172 of the present number.

SOCIETY OF ARTS PRIZES.

The Council of the Society of Arts are prepared to award the following prizes in connection with the International Inventions Exhibition:—

John Stock Prize.

Under the John Stock Trust, a Society's Gold Medal, for the best application of Photography to a Permanent Printing Process, Group XXVI., Class 140; Group XXIX., Class 159.

Group XXVI., Class 140. *Letterpress and other Printing.*—Printing machines and presses; glazing and hot-pressing apparatus; apparatus, &c., for type-founding; lithographic machinery, materials &c.; stereotyping apparatus, &c., methods of anastatic printing; process blocks from autographic drawings; wood blocks; engraving machines; machines for cutting wood letter; type-setting machines, numbering machines, printers' furniture and locking-up appliances; production of printing surfaces; methods of printing cheques, banknotes, &c.

Group XXIX., Class 159. *Processes and their results.* — Methods of gelatino-bromide plate-making, apparatus for making emulsion, apparatus for separating the sensitive constituent, coating, drying and packing machines; emulsion and other processes; printing processes, silver, carbon, Woodbury-type, platinotype, gelatino-bromide, collodio-chloride of silver, &c.; apparatus for washing, &c.; prints and negatives; methods for making photographic lantern slides.

Howard Prizes.

Under the Howard Trust, five Gold Medals, for the best exhibits (coming within the terms of the Trust*) in the following Classes:—One for the best exhibit in Group IV., Class 26. One for the best exhibit in Group IV., Class 27. One for the best exhibit in Group IV., Class 28. One for the best exhibit in Group XI., Classes 59 to 62. One for the best exhibit in Group XIII., Class 72.

Group IV.—Prime Movers, and Means of Distributing Their Power.

Class 26. *Steam-engines and Boilers.*—Stationary, portable, marine, locomotive; fireless locomotives; methods and means of preventing corrosion and incrustation; methods and appliances for preventing explosions, and for testing boilers; firegrates, fire-feeders, smoke-consuming appliances; valves and valve gear, steam joints, governors, injectors, pumps; bearings, lubricators, anti-friction metals; indicators, gauges, manometers, tachometers, dynamo-meters.

Class 27. *Gas and Air Engines,* &c.—Gas-engines, hot-air engines, petroleum-engines; air-compressors, compressed air-engines; ammonia-engines, vapour-engines; accessories for the above.

Class 28. *Means of Utilising Natural Forces.*—Turbines, water-wheels, tide-mills; means of utilising wave-power; hydraulic rams, water-pressure engines; windmills; solar engines.

* The Trust was left "for the purpose of presenting periodically a prize or medal to the author of a treatise on the properties of Steam generally, or any of them particularly, as applied to motive-power, or it may be of air or permanent gases, or vapours, or other agents so applied, or to the Inventor of some new and valuable process relating thereto."

Group XI.—Hydraulic Machines, Presses, Machines for Raising Heavy Weights, Weighing, &c.

Class 59. *Pumps, Hand, Steam, Rotary, Centrifugal.*—Ships' pumps, pumps for corrosive fluids; hydropults; syphons; methods of raising water; methods of obtaining, distributing, and equalising hydraulic power; accumulators.

Class 60. *Fire-engines.*—Fire-extinguishing apparatus; automatic apparatus for indicating and extinguishing fires; fire-escapes, ladders, fire hose, accessory fittings and appliances; hydrants.

Class 61. *Cranes and other Lifting Apparatus.*—Hand, steam, and hydraulic cranes; travellers; elevators, jacks, capstans, windlasses, crabs, hoists, blocks, pulleys, derricks.

Class 62. *Hydraulic and other Presses.*

Group XIII.—Electricity.

Class 72. *Distribution and Utilisation of Power.*—Electric railways, electric motors, electrically driven boats, tricycles, and other conveyances; systems of distribution.

Fothergill Prize.

Under the Fothergill Trust, one Gold Medal for the most novel and best exhibit in Group XXVIII., "Philosophical Instruments and Apparatus," Classes 148 to 158.

Class 148. *Optical.*—Lenses, prisms, telescopes, microscopes and accessories, spectroscopes, polariscopes, polarimeters, stereoscopes, photographic lenses, spectacles, eye-glasses, optical glasses.

Class 149. *Astronomical.*—Telescopes (astronomical), transit instruments, equatorials, mural circles, driving clocks, siderostats, heliostats, altazimuths, methods of fitting observatories and mounting instruments.

Class 150. *Physical.*—Acoustic apparatus, tuning forks, sirens, phonautographs, phonographs; apparatus connected with molecular physics, air-pumps, manometers, radiometers; apparatus for measuring, &c., heat, thermometers, pyrometers, calorimeters; photometers; kinematic, static, and dynamical apparatus; mechanics.

Class 151. *Electrical.*—Friction and induction machines, batteries and other sources of electricity, Leyden jars, condensers, electroscopes, electrometers, galvanometers, voltameters, dynamometers, magnetometers, rheostats, resistances, electrical units, induction coils, thermopiles, vacuum tubes.

Class 152. *Chemical.* — Thermometers, hydrometers, pyrometers, furnaces, blowpipe apparatus, assaying apparatus, apparatus for organic and inorganic analysis, for gas analysis, and for volumetric analysis, labor tory fittings and apparatus generally, balances, reagents.

Class 153. *Mathematical.*—Calculating machines, indicating and registering apparatus, pedometers, counting machines, slide rules, planimeters, drawing instruments, ellipsographs, straight-edges, gauges, surface planes, dividing engines, pantographs, eidographs.

Class 154. *Meteorological.*—Barometers, thermometers, rain gauges, manometers, hygrometers, aneroids, anemometers, ozonometers, storm signalling apparatus.

Class 155. *Geographical.*—Surveying apparatus, theodolites, chains, levels; underground surveying apparatus; apparatus for hydrographic surveying, and for marine investigations and observations; hypsometrical instruments, tide gauges; seismographical apparatus; projections, maps, charts, models, and globes.

Class 156. *Nautical.*—Sextants, quadrants, sounding apparatus, logs, compasses.

Class 157. *Weighing and Measuring.*—Weights, scales, balances; measures of length, graduated scales, verniers, steel tapes; measures of capacity; instruments for angular measurement, clinometers, goniometers.

Class 158. *Biological.*—Apparatus for anatomical research; physiological apparatus; apparatus for collecting and preserving natural history specimens.

Alfred Davis Prize.

Under the Alfred Davis Trust, three Gold Medals to be awarded in Division II. of the Exhibition (Music), Groups XXXII. to XXXIV., Classes 166 to 180.

Group XXXII.—Instruments and Appliances Constructed or in Use Since 1800.

Class 166. *Organs.* — Details of construction; machines for blowing, hydraulic or otherwise; details of mechanism, and the construction of pipes; pneumatic apparatus for key boards and couplers; electric appliances, designs for organs, designs for organ cases.

Class 167. *Harmoniums.*—American organs, vocalions, concertinas, accordions, varieties of reeds and air-channels, details of construction.

Class 168. *Wind Orchestral Instruments.*—(*a*) Wood; (*b*) Brass.

Class 169. *Pianofortes* (Grand, square, and upright).—Models of framings, castings, models of actions, pedal appliances, mechanical devices for tuning and transposing, wire and other material used in construction, designs for cases.

Class 170. *Violins, and Instruments of the Violin Family.*—Bows, strings, and inventions connected with these instruments.

Class 171. *Harps.*

Class 172. *Automatic and Barrel Instruments.*

Class 173. *Drums, Cymbals, and other Instruments of Percussion.*

Class 174. *Bells and Carillons.*

Class 175. *National Instruments of all Countries not ordinarily used in Orchestras.*

Class 176. *Sirens, Tuning Forks, Pitch Pipes,*

Tonometers, and appliances for the determination of pitch.

Class 177. *Miscellaneous Musical Appliances.*—Metronomes, desks, seats, appliances for forming the hand; instruments for recording improvisation.

GROUP XXXIII.—MUSICAL ENGRAVING AND PRINTING.

Class 178. *Printed and Engraved Music: and Machines and Appliances for its Production.*

Proceedings of the Society.

CANTOR LECTURES.

ON THE USE OF COAL GAS.

BY HAROLD DIXON, M.A.

Lecture III.—Delivered December 15, 1884.

With your permission, I should like to say a few words as a preliminary to this lecture, on a subject that has been much debated, the effect on different sources of light, of haze and fog. Some of this audience are aware that experiments have been carried on during the past year at the South Foreland on this subject, and that various illuminants have been tested with regard to their penetrative power through mist and fog; and although the investigation is not over, and I am not in a position to give precise results, I can make a few general remarks on the subject. I am often told—"So, I hear the electric light is absorbed by a fog; it is no use." That statement is not really correct. The electric light does go through a fog as well as another light, if it is as bright in the red rays, the less refrangible rays, as the other light is. There is a popular fallacy, and many writers commit it, in supposing that the absorption of light is independent of the quality of the light; whereas the absorption of light takes place selectively, just as the absorption of heat takes place selectively. When a beam of heat falls on a plate of glass, it suffers a certain per-centage of absorption; the beam which has filtered through the first glass suffers less absorption in passing through a second plate of glass, and still less in passing through a third. And in the same way Professor Langley has shown that light suffers a selective absorption. Where a beam of light passes through any medium, such as a plate of glass, it suffers a certain per-centage of absorption; the beam of light which has passed through the first suffers a less percentage of absorption passing through a second plate of glass, and still less in passing through a third, and so on. In other words, the beam when it has lost its absorbable constituents then suffers less than it did at starting. Now the bearing of this with regard to the penetrative power of the electric and other lights is this. If the electric light is stronger in the long rays than another source of light, produced by gas or oil, and it passes through a certain thickness of haze, it loses its absorbable constituents, but the residual light is stronger than the residual light from the other source, and, therefore, that residual light will pass further through haze, than light from the gas or oil. But if the two are of equal intensity to start with—that is to say, if the two equally affect a photometer disc—and the two lights pass through a certain thickness of haze, then the electric light loses more of its constituents than the oil or gas light, and, therefore, the residue is less strong than the residue of the gas or oil, Taking, then, two lights of equal intensity, one electric and the other gas light, the latter will go further through haze. But if the electric light is very much stronger, as electric light can be made, than any gas flame or oil flame, then, in spite of its greater absorption, it will go further than those other weaker flames. I said that there was a fallacy in the usual way of expressing the absorption of light. The fallacy consists in regarding the absorption as *regular*. If a is the intensity of the source of light, and x the fraction of that which passes through one layer of haze, and y is the number of layers through which it passes, then it is ordinarily said that the light which passes through any number of layers, y, and comes to the observer's eye, is expressed by $a\,x^y$. But in reality, the absorption is not regular. The loss of light is greater at first, and becomes less and less as the shorter waves are filtered out of the beam.

When a gas flame burning in air is allowed to mix itself with air, it loses light. I showed you experiments last week, in which coal gas, forced out through a small orifice at high pressure, mixed itself with the air, and gave less light than when it flowed with a gentler stream through the opening. Now, if we mix air with the coal gas before it reaches the orifice, we also find that it gives less illumination. A burner has been constructed which is commonly called by chemists a Bunsen burner, after Professor Bunsen, of Heidelberg, but is now usually referred to as an atmos-

pheric burner, in which air is mixed with with coal gas before it is burnt. On the table there are several of these burners, made of a straight piece of metal pipe, with orifices near the bottom; the gas issues from a small hole into this straight pipe, and passing upwards, draws in a current of air through the holes, two or three as the case may be, in the pipe. The coal gas thus mixes itself with about twice or two and a-half times its volume of air, and burns with a non-luminous blue flame. The Bunsen burner gives a flame which will deposit no soot on any solid body held in it; it gives a flame with hardly any light, its non-luminosity, of course, being dependent on the fact that no carbon is separated in the burning of the gas. To get a luminous flame, the hydrogen of the hydrocarbons in the coal gas must burn before the carbon; the carbon must be separated and strongly heated up before it is finally burnt to carbonic acid. In the Bunsen burner the carbon and hydrogen burn together; the hydrogen does not have that start of the carbon which it has in the ordinary flame. But, although we are very familiar with this Bunsen flame, the reason of it is not so obvious. It used to be always explained in this way, that the oxygen of the air, being allowed to mix with the coal gas before it issued, burnt or oxidised the carbon straight to carbonic acid, without giving it a chance of existing in the solid state unburnt. But although that is a partial explanation, it is not the whole matter. Here is a pipe with the holes at the bottom closed, so that no air can get in; the gas is burning with the ordinary luminous smoky flame. If, instead of allowing air to enter the flame we pass in some gas which will not aid the combustion, such as carbonic acid, we find that the flame loses its light, and becomes very much like an ordinary Bunsen flame. I have here attached a Kipps apparatus for generating carbonic acid, so that I can pour carbonic acid into the stream of gas, and let the two burn together. You notice that as the carbonic acid mixes with the coal gas the flame loses its light, turns blue, and is hardly distinguishable from the flame of the ordinary atmospheric burner. Now, this effect cannot be due to the oxidation of the carbon by letting in air, because I am letting in no air, but only carbonic acid. If I continue to increase the supply of carbonic acid, the flame gets bluer, and is finally extinguished. The air which is admitted to a Bunsen burner acts not only by oxidising the carbon directly to carbonic acid, but also by this dilution of the coal gas, and the effect of the carbonic acid, I think, in this experiment is twofold; it dilutes the gas—it separates the particles of the gas from one another—and it also cools down the flame. Both causes tend to destroy the illuminating power of the flame. In the first place the dilution, by increasing the distance between the carbon atoms, prevents their aggregation, and, secondly, the presence of this inert gas, taking no part in the combustion, absorbs heat, and, therefore, cools down the flame. Both these effects are found in the Bunsen burner, besides the oxidation. I think then the reason why the Bunsen burner is not luminous is, first, that the carbon is oxidised by the oxygen of the air let into it; secondly, that the coal gas is diluted by the nitrogen of the air admitted; and, thirdly, the flame is cooled down. The Bunsen flame is not cooled below the temperature of the luminous flame—it is hotter than the luminous flame—but it is cooled down below the temperature of a gas flame mixed with undiluted oxygen. When a little pure oxygen is mixed with coal gas, it burns with a more luminous flame, owing to the increase of temperature in spite of the direct oxidation of some of the carbon. I can show you an experiment on this point, proving that the mere presence of a small quantity of oxygen is not sufficient to weaken the luminosity. Here is a burner with a supply of coal gas, in the centre of which a small tube is fixed, through which I can bring a supply of oxygen to the flame. I gradually bring into the flame a little oxygen, when we see that the intensity of the light is very much increased. It is evident that the mere presence of oxygen in the flame need not necessarily, by oxidation, destroy the light. Now, I increase the supply of oxygen to this burner, and we find that as the oxygen increases the light gradually diminishes, and we shall finally get a small non-luminous flame, of a very high temperature. As the oxygen is turned up, you see the character of the flame is altered. It no longer gives light; it burns with a blue-violet flame, and the tip is green.

The high temperature produced by the burning of coal gas, either in air or oxygen, has been utilised for producing an artificial light. Let me show you one or two simple experiments on the temperature of this flame. Platinum you know is a most refractory substance, melting at the highest temperature any known metal. On introducing a spiral of platinum wire into this flame, it is immediately melted. Here is a little cylinder of

lime against which this non-luminous flame is caused to impinge, and here we have the well known lime-light, or Drummond light. Now two burners not dissimilar to this in principle have lately been devised, one by Mr. Lewis, and the other by M. Clamont, which depend on the high temperature produced by the burning of coal gas in a supply of air. I will turn off the oxygen from this coal gas flame, and instead introduce a blast of air. The temperature obtained by this means is of course not so high as that which you saw melted the platinum readily, but still we get a very high temperature. When the air is blown in, we get a non-luminous flame, and if I introduce a bit of platinum, of the same thickness as was melted just now, it gets heated up to a bright red; with a rather thinner coil of wire the light emitted is much whiter. This in effect is the platinum lamp of Mr. Lewis. I have not got, I am sorry to say, the lamp itself to show you, but it is made by blowing air into a coal gas flame, and letting it play on a little cage of platinum wire in exactly the way I showed you just now; only I believe he has succeeded in making the blast of air enter the flame without making that hissing noise, at all events, in so marked a degree as you heard just now. I have only once had the pleasure of seeing the Lewis gas supplied on a large scale, and then I do not think it was quite free from the hissing noise—it was just noticeable. I believe Mr. Lewis is now lighting some of the stations on the Underground line, and probably many of my audience are more familiar with the light than I am myself. In the Clamont light, the chief difference is this, that magnesia, the oxide of magnesium, is heated up by the blow-pipe flame—for it is nothing but a blow-pipe flame—a current of air blown through coal gas. Magnesia, like lime, glows, when heated, with an intense white light. Of course the chief objection to both these burners being brought into large use is this, that a supply of air at high pressure is necessary, so that either one must have a blower to send in the current of air, or else a double set of mains must be laid down from the central supply.

The two flames we have considered—the luminous gas flame, and the non-luminous Bunsen flame—have both their uses, the one chiefly as a source of light, the other as a source of heat. The luminous flame I have already discussed, and I want now more fully to consider the applications of the non-luminous in heating and cooking.

We have seen that when a solid substance is placed in the non-luminous flame it glows brightly, and gives out far more light than the non-luminous flame itself. Without any artificial supply of air under pressure, this Bunsen flame will heat up a coil of platinum wire to a bright incandescence. The luminous gas flame containing solid particles of carbon will radiate heat much more strongly than a non-luminous Bunsen flame. Heated gas by itself is almost incapable of radiating heat. Solid particles are necessary for radiation. Now in the ordinary flame we have solid particles of carbon, and it is the solid carbon which gives the radiant heat. In the non-luminous flame we have no solid particles, and we, therefore, have very little radiant heat. But if we consider the temperature of the flame alone, we find that a Bunsen flame is of a higher average temperature than the luminous flame. It gives out, actually, the same quantity of heat when the same quantity of gas is burnt, but, since in the Bunsen flame the combustion takes place in a smaller space, the average temperature of the flame is higher, so that a coil of platinum wire held in it will be raised to a higher temperature than if held in an ordinary luminous flame. Now, the Bunsen flame may be used as a source of radiant heat, by heating up a solid body, such as platinum, fire-brick, asbestos, or other incombustible substance. The Bunsen burner may also be used as a source of heat, by applying the flame directly to a vessel in which water or other material is contained. If we want to boil water, certainly the easiest and cleanest way is to place a kettle over a Bunsen flame; no soot is deposited, for there are no solid particles of carbon in the flame, and the kettle remains clean. Of the various kinds of Bunsen burners which have been devised to heat water, those constructed by Mr. Fletcher, of which I have several specimens here, seem to me to be admirably fitted to that purpose. I have no doubt that others may be as good, but I am not so well acquainted with them. I have here two specimens of the simplest form of burner, in which the gas flowing from a small pipe creates a partial vacuum, and draws in the necessary supply of air, so that the air and coal gas mix in the base of the burner, and then burn with a non-luminous flame. These burners are very easily regulated; you can get a very small flame or a very big flame as required. For the purposes of cooking, this Bunsen burner seems to be most admirably adapted, wherever water is to be

boiled, and wherever food is to be baked or braised; but there is a difference of opinion with regard to roasting, and I do not feel myself in a position to be able to lay down the law at all on this subject. My chief experience with regard to cooking has been with a Bunsen burner. Now a Bunsen burner will roast meat very well, provided that the products of combustion are not poured straight on to whatever is being cooked; the flame must be used to heat up the walls of the roaster, and the radiant heat from the walls must roast the meat. Such, I think, is the right way in which to roast meat if you use a Bunsen burner; do not place the joint straight over the top of the burner so that the carbonic acid and steam pass directly on to the meat, but have the burners arranged alongside the walls of the roaster, and so heat up the walls as to cook the joint by radiant heat, and not simply by heated gases. In some forms of gas oven the air inside the oven is heated up, and this air, with the products of combustion of the coal gas, bakes the joint, but that I think is not the best way of doing it. The other way is to allow a constant supply of air to pass through the roaster, coming in at the bottom and passing out at the top, mixed with the products of combustion; and to cook the joint by the heat radiated from the sides of the roaster. By the kindness of Mr. Fletcher I am able to show a stove—a kitchener, perhaps, I should call it—in which the Bunsen or atmospheric burner is alone employed. The roaster itself is quite open at the bottom, so that a continual supply of fresh air is sweeping in, and passing out at the top with the products of combustion. There are two small rows of gas burners heating up the opposite sides of the roaster, and the radiant heat from them roasts the joint between them. On the top of the roaster three burners are placed, over which kettles and saucepans may be boiled. Underneath these burners, between them and the roaster, is a space for cooking chops or grilling steaks, and so on. One of these burners is made to rotate so that the flame can be turned either upwards or downwards. When you want to grill, the burner is turned over, the iron is then above the flame, and becomes strongly heated, and the radiant heat from it grills the chop; on turning the burner over, the flame being above, it can be used for boiling or braising.

Now, in an arrangement where such a gas stove as this replaces the ordinary kitchen fireplace, I venture to think that great economy will be found; not that coal gas is so cheap that we cannot get a greater quantity of heat by burning coal of the same value, but because the whole thing is so clean and easy to work. First of all, we have no pouring coals into the cellar, we have no digging coals out of the cellar, we have no dust and cinders to clear away; secondly, the stove is only alight when it is required. It is not necessary to keep the kitchen fire burning all day, because you can light the gas in a moment, and in ten minutes it is ready for use. The third advantage of the gas system in the house is this, that you do away altogether with what I may call the *bête noir* of domestic life, the kitchen boiler. With water as we have it supplied in England, with a certain quantity of magnesium and calcium salts dissolved in it, the kitchen boiler has a crust continually forming on it, and it requires periodical cleaning out. Unless this is done there is always a danger of the fur blocking up the supply pipe, and causing a dangerous pressure of steam. Another danger, too, may occur, the crust forms all over the inside of the boiler, and increases day by day as the water is heated in it, and may become of such a thickness that the iron of which the boiler is made, being cut off from contact with the water, may become red-hot. If then some of the fur breaks off, the water may come in contact with the red-hot iron, and the sudden evolution of steam consequent on that may be sufficient to burst the boiler. Now, in an arrangement which I should recommend, the kitchen boiler is done away with altogether, just as the kitchen fire is done away with in favour of the gas oven. Hot water is obtained where it is wanted by a therma, or water heater, one upstairs for baths, and the other downstairs for washing up. By the kindness of Mr. Sugg I am able to show you here a very perfect specimen of the water heater, designed by Mr. Vernon Harcourt. In it a ring of gas burners is lighted at the bottom; at the top the cold water flows into a sieve, whence it passes in fine spray, and falls on a metal plate; through the middle of this metallic plate it passes through an orifice on to a second plate; it flows along that and falls off around the circumference on to a third plate, through the middle of which it passes, and so on. The products of combustion, the steam, and carbonic acid from the coal gas, pass upward through this series of water falls, and the heat of the gas is thus absorbed by the water, the products of combustion passing off at the top quite cool. The supply of gas

and water must be so regulated that before the water reaches the bottom it is raised to the temperature required, about 110° F. or 120 F., which is sufficiently hot for ordinary purposes, for a bath or washing up dishes. In this way, in ten minutes a bath may be supplied with hot water, no iron pipes need pass through the house from the kitchen upstairs, because the water is heated *in situ*. A similar therma may be placed in the kitchen, where hot water is required, perhaps, more abundantly than upstairs. With these devices, the hot water apparatus, and the gas stove, the burning of coal for cooking and heating is quite got rid of. I ought, perhaps, to say a few words on the other system of roasting by gas—that of heating by radiation direct from the gas flame. That is the method which has been used by Mr. Sugg in his gas kitcheners. His, I believe, are generally made of copper. He has two rows of luminous gas jets, one in front and the other behind, and the joint is made to turn on a spit between them. In this way, the radiant heat of the luminous flames roast the joint. He claims for it that the joint has a better flavour than it has when it is cooked by a Bunsen burner. My own experience is that joints cooked in Mr. Fletcher's stoves have a most excellent flavour, certainly quite as good as when roasted before an ordinary fire. I have tasted joints cooked in gas ovens, improperly cooked, because the supply of air was not sufficient; the meats were really baked in that case by hot air, and were not roasted by radiation, and I think that made all the difference. In these roasters the meat is entirely cooked by radiation. That all the dainties I propose to show you cooking in this stove will turn out successfully, I will not venture to predict, because I am a very inexperienced cook, but I may say this, that a bachelor may grill a steak or a chop with a gas stove, and be perfectly satisfied with it. In this gas kitchener I have been roasting a leg of mutton, baking potatoes and a fruit tart, and making tomato soup, and if those who are experienced in domestic cookery will kindly pronounce upon them afterwards they shall be placed at their disposal.

Just a word or two about the ventilation of rooms by the ordinary English method of a coal fire, aided by crevices under the doors and in the window sashes, and the system of ventilation and lighting a room at once as it can very well be done by coal gas. The ordinary method of ventilating a room I have called the English method, an open coal fire, aided by the crevices under the door, because in the vast majority of houses we go into in England we find that such is the only method of ventilation provided.

What happens in such a room is this. If the fire burns well it will draw in some thousand cubic feet of air an hour, a little more or less, and that will be supplied not from the general air of the room, but from the lowest stratum of air in the room, that on a level with our feet. The air in the upper part of the room will remain unaffected, and only the air low down near the floor will be drawn into the fire. Now the air which flows in to fill this space will pass in under the door, through the key-hole, or any other small crack, where it can find entrance, and many are the colds and unpleasant consequences produced by this method. It does produce a draught certainly in the room, but it does not change the air we are breathing so well as if we had a very much smaller ventilating power placed in the upper portion of the room. Now, if a room were lighted with such a regenerative burner as I showed you last Monday, where the air was continually drawn in to feed the coal gas flame, and then, mixed with the products of combustion, passed away through a pipe, we should have a continual change of air in the upper parts of the room, exactly where the change is required. The heated products of combustion of any flame in a room, be it candle or lamp, or coal gas, are lighter than ordinary air, and pass up to the ceiling, and so does the breath from the people in the room. The consequence is that in an ordinary room the impure air is near the ceiling, and the purer air near the floor. It is not important to change the air near the floor, it is important to change it in the upper part of the room. Now, a gas burner in which the products of combustion are drawn away, does so ventilate a room by changing the air at the top. Where a burner carrying off its products of combustion cannot easily be placed in a room, it is easy to place a ventilator near the cornice to carry off the vitiated air. The heated gases from the gas flame, or whatever other flame is used to light the room, must pass towards the ceiling, and if we give them there an orifice to escape by, they will escape by it. But we must remember one thing; one must supply continually a stream of fresh air to take the place of the air so drawn off, and we must not allow the air to force itself in through nooks and crannies, and so produce draughts. What we want in ventilation is a large body of air flowing gently through

a large opening. In this way draughts are avoided, and the fresh air spreads itself out quietly throughout the whole room. I think one of the best systems of ventilation is that in which the in-currents of air are brought up by a large pipe, and allowed to flow out some 7 or 8 ft. from the floor. As it is brought into the room it has an upward flow which throws it out towards the ceiling. Such a current of air will not have sufficient force to flow right up to the ceiling, and mix with the products of combustion and hotter air derived from the gas flames, but it will form a layer under these, and will then gradually subside all over the room. Some of it will, of course, be drawn to the gas burner, and will there be burnt, and it will then pass to the ceiling. Another portion will pass downwards and feed the fire, and that will pass up the chimney. The important part of such an arrangement is this, that the fresh air is brought in at two-thirds of the height of the room, and spreading itself out evenly over the room, feeds both the gas flames and the fire, and the people in it. Now in such a system of ventilation the gas flame in the room plays an important part. Even if we cannot have that which I think is the best system, a regenerative burner carrying of its products of combustion, and so producing an artificial ventilation, we can have ordinary gas burners and orifices near the ceiling to carry off the heated air.*

Among the apparatus for heating and ventilation worked by gas, is one which works very successfully, called the "Lux Calor;" it gives both light and warms the air. In the centre is a ring burner. The products of combustion pass upwards, and then turning over, pass downwards through the annular space between two metal cylinders. These cylinders are in contact inside and outside with the air of the room, so that whatever will be condensed out of the products of combustion by cooling are condensed in the apparatus. We find that water mixed with some carbonic acid, and a small quantity of sulphurous acid from the sulphur of the coal gas flows in drops from the bottom of the apparatus. Air is continually passing through the cylinders, and is warmed up in its passage. The cylinders between which the hot products of combustion of coal gas are passing, heat up the air in contact with them, so that the air becomes lighter than the corresponding column of air outside, and rises. Accordingly we have a continual draught in of fresh air at the bottom, and warm air passing out at the top. It does not come anywhere in contact with the products of combustion of the coal gas, but merely in contact with the hot sides of the cylinders. The air then in the room continually passes through these copper cylinders, and so becomes warmed. The apparatus may also be arranged so as to bring in a supply of fresh air from the outside of the house, and warm it in bringing it in. At the back of the apparatus is a hole, to which can be attached a pipe from the outer air, and through this pipe the air is drawn; it would pass through this system of cylinders, and is warmed in its passage. The burner itself having a glass sheet in front, or else being open gives light, and the whole apparatus may stand in a passage or office, and both light and warm the air in it.

Now, I am not so thorough-going an advocate of coal gas as to wish that our coal fires should be entirely abolished. I confess that I like poking a fire, and I know many people share my prejudice, but there are many rooms, bedrooms for instance, where one would be very glad to light up a fire on going to bed, or on rising in the morning, without the trouble of having a coal fire laid. For such a purpose I think an asbestos fire answers most admirably. It is made in this way. One has an atmosphere flame, that is to say, coal gas mixing itself with air, and burning with this non-luminous flame, and in the flame is placed a fire brick, or asbestos, or some incombustible substance. On the table I have such an asbestos grate. In the front of it is a pipe bringing in the coal gas, so that the atmospheric flame plays over a quantity of asbestos fastened in between the crannies of fire brick placed at the back of it. It is lit in a moment; it gives out plenty of radiant heat, which is the

* At the end of the first lecture of this course there is an omission which I take the opportunity of supplying. In speaking of the formation of sulphuric acid from the sulphur in coal gas, I said that no condensation of steam, and consequently no oxidation of the sulphurous acid, could take place in a room, to which the necessary air supply was maintained. I omitted to state that the air supply for ordinary ventilation should be such as to keep the quantity of carbonic acid present in the room below a certain small *maximum*. If 10 cubic feet of gas are burnt per hour in a room of 2,500 cubic feet capacity, the whole of the air must be renewed once in two hours in order that the quantity of carbonic acid in the atmosphere of the room may not exceed ·5 per cent. If the ventilation is such as to cause this renewal of the atmosphere, then the steam produced by the burning of the coal gas will not exceed 1 per cent. of the atmosphere, and will pass away uncondensed.

kind of heat we want; and I think it presents a very agreeable appearance. And not only that, it serves perfectly well for boiling a kettle, which can be placed in front of it on a little hob provided for the purpose. What we want in a fireplace chiefly is radiant heat. We do not want the Continental gas stove, which gives us simply hot air in the room. English people are accustomed to be warmed by radiation, and to live in cool air. It oppresses us to pass into a room where the air is heated; we like to inhale cool air, but we like to feel the wall and other objects in the room to be warm. This, of course, is effected by radiation. Radiant heat passes directly through ordinary air without heating it in any appreciable degree; air is only heated when in comes *in contact* with hot substances. Now, such a fire as I have on the table, gives out radiant heat through the device of placing in a non-luminous Bunsen flame, a solid substance which is raised up to a bright red heat, and then radiates heat. Such a stove, I think, is suitable for many rooms in a house not frequently lived in. I do not think it is quite a satisfactory substitute for a sitting-room fire. But consider for a moment what the effect would be if the kitchen fires of all London houses were abolished, with their boilers and other abominations, and if one half the other fires were also abolished and replaced by such stoves as I have shown you this evening. These stoves have been standing in the room unconnected by any pipe to the chimney, and nobody can see any products of combustion coming from them. The coal gas in them is perfectly burnt, and passes away as steam and carbonic acid. With such heating arrangements as these we should have no smoke, and with no smoke in London we should have no London fog. We should have fog, but we should not have that particular article called "London" fog, in which the particles of moisture which make up the mist become coated with a carbonaceous sulphurous cuticle. This acrid sooty scum is that which gives it that particular character which has earned the London fog its notoriety. The English Channel has quite as many fogs in it, perhaps more than London has, but the fog in the English Channel is a clean white mist; it wets you a little, but when it has passed away you are none the worse, whereas London fog, owing to this cuticle of dense smoke upon it, is one of the most deleterious things of modern civilisation. Now, the moderate use of coal gas would very greatly, I think, diminish the evils of the London fog, and, I think, it would not at all diminish the comfort of our houses. I think that such a stove as Mr. Fletcher has lent me this evening, and with such a heater as Mr. Harcourt has devised, we might get on very comfortably in our houses, and I think with such an asbestos stove in our bedrooms we should be more comfortable than we generally are. At the same time we should have the satisfaction of knowing that we were preserving the atmosphere free from taint, and not choking our neighbours with our kitchen smoke.

In bringing this course of lectures to a conclusion, I have to thank the gentlemen who have so kindly placed their apparatus at my disposal, especially Sir James Douglass, for that brilliant lighthouse burner he lent me; Mr. Fletcher for these stoves and burners; Mr. Sugg for many admirable burners; and Messrs. Ritchie for this heating and lighting stove, and to all of you for the very great attention with which you have listened to me.

A vote of thanks to the lecturer having been passed unanimously, on the proposal of the chairman (Mr. B. F. Cobb),

Mr. Harold Dixon said—By way of reply, perhaps I may read a short abstract from my note-book of the cost of such a system as I have attempted to explain to-night of cooking and heating entirely by gas. These figures are obtained from the house of a friend of mine in Oxford, whose hospitality is well known, and whose table, as I can vouch for, is of the best. He tells me has done all his cooking, for the last three years, in a Fletcher gas roaster, and he has heated all the water used in his house in a therma similar to this, not the same, but one of Mr. Fletcher's; and in his kitchen he has adopted a boiler something like a large saucepan, with a coal gas flame underneath. The cost of that, on the average for a household of eleven persons, including twelve gas burners, because he employs gas in the kitchen, scullery, passage, hall, and consulting room, is £28 a year. This is an average of three years' consumption. It seems to me, if one considers what is the average amount of coal burnt in a kitchen fire for a family of 11 persons, and consider what the coal gas burnt at twelve burners constantly alight is, that the sum becomes exceedingly small. The following is the list of apparatus worked by the gas—one large cooking stove, and one small one, one boiler, five Bunsen ring burners, and two water heaters. This is all done for £28 a year, but I must mention that the price of coal gas in Oxford is only 2s. 8d. per thousand feet.

JUVENILE LECTURES.

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By J. Norman Lockyer, F.R.S.

Delivered Wednesday, December 31st, 1884.

Once upon a time, ages ago, when the world was very much younger than it is now, and when there were very many more elves and fairies than there are now, and even long before Santa Claus was born, and was going about as we hope she will be going about so merrily to-night—all that while ago I say you can quite understand that people had not any clocks and watches. They did not seem to care very much about time, and indeed, it was long before they found out how properly to take note of it. If any of you care to remember, I may just say that it is about 2,300 years ago that people did begin to take some effective interest in time, and the man that began it was named Berosus. It is not quite certain that he was the first, but it is very probable; he was a very wise man, a Babylonian, and he made an arrangement which I can illustrate to you by this lamp glass. He took such a cup-shaped thing, and stuck a peg in the middle of it, and as he lived in a place where the sun nearly always shines brightly, of course as the sun rose in the east it threw the shadow of this peg on the western side of the cup, and when the sun set in the west it threw the shadow of the peg on to the east side of the cup, and of course between the east and west it had to throw the shadow somewhere between those two points. That sounds all very easy, but what Berosus found, and what people found who came after him, was this, that the sun only rises exactly in the east, and sets exactly in the west on two days in the year, and that sometimes, in summer for instance, the shadow of this peg at noon was found at a very different height in the cup to what it would be at noon in the middle of winter. You know, as well as I do, that in summer and winter there is a very great deal of difference in the time that the sun is visible to us. We all know that in winter the days are short, and that in summer the days are long, and naturally, therefore, in winter the nights are long, and the days are short. Now Berosus and those who came after him could not very well get over that from our point of view, but they got over it a certain way, and their way was this. They said—Well, we will say there are 12 hours from sunrise to sunset, and 12 hours from sunset to sunrise, and if it so happens that the days are twice as long in summer as they are in the winter, then in summer we will make the hours twice as long; so that in summer they had 12 long hours in the day, and in winter they had 12 short hours in the day. That was the time to go to school, in the winter when the hours were short! But suppose now-a-days we had these unequal hours; fancy looking at Bradshaw to know which train to take to go home when the length of every hour must vary for each of two sets of days in the year. It is a curious thing, but it took a great many hundreds of years before people got out of this unequal hour arrangement.

Now I will give you another date, which will bring you nearer home. In the year 1284 or thereabouts—it was really 1288, but we will call it 1284 so as to make it exactly 600 years ago—there was a very naughty Lord Chief Justice of England. I do not know exactly what he did; I believe he falsified a record, and made a poor dependant pay 13s. 4d. instead of 6s. 8d., or something of that kind; but because he did, and because the authorities were very anxious then to show that even the great must be just, he was to pay a very heavy fine, and they determined that the fine he should pay should be enough to build a clock, and the clock built with that money was, as far as we know, the first clock which existed in England. It was erected in Westminster, and it only disappeared, some parts of the tower at least, with its motto, "Discite Justitiam Moniti," a very few years ago. Then clocks got more and more elaborate, and more and more perfect down to our own time. I do not propose to go into the history of clocks. Many of you know all about clocks, but some little girls may not know all about them; therefore, I want to show you, as shortly as possible, what are the principles which regulate both our clocks and watches, as they are made by the best people to-day.

Now, a clock is really a very simple thing. We begin with the clock first. It is simply a train of wheel-work, which is driven by a weight or a spring, and it is so arranged that, if you only had the train of wheel-work, when the weight began to fall, or the spring to act, all the wheels would turn round, and very quickly. They are all geared into each other, so that one wheel goes at a certain rate of speed, another goes sixty times faster, and another goes sixty times faster again; I repeat, if you simply had that clockwork, and the

weight, the wheels would go round and round, and make an awful noise, such as, I dare say, you have heard when you have broken the balance spring of a watch. If you only had a clock like that, you would have to keep winding it up all the time. What you have to do is to let it go very slowly, and you have to do that by adopting an arrangement which will arrest the train of wheels with the most absolute regularity. I am going to show you here a model of a modern clock which shows how the train of wheels is acted upon by the regulator. [The lecturer here described the model of a clock escapement, showing the manner in which the escape wheel was allowed to move, only one cog at a time, by the action of the pallets attached to the pendulum.] I have here an arrangement which is not an entire clock, but the principal part of it, and shows how the pendulum manages the business and controls the clock. If that pendulum does not work with the most absolute regularity, the clock will not go well, but if the pendulum does work with perfect accuracy, your clock must be almost perfect. Now the construction of a pendulum is a very complicated affair, because, as many of you know, who are studying physics at school, metals—and most pendulums are made of metal—expand by heat and contract by cold, so that your pendulum will get gradually longer and shorter, not very much, but a little, according to the temperature. Now that has to be corrected. I have not time to tell you how the clockmakers have managed to get such a compensation in the pendulum, that, whatever the temperature may be, the length of the pendulum is practically the same, and, therefore, the rate of the clock is not disturbed by temperature. There is also another arrangement which it is worth while to call your attention to, because it will show you, and I think nothing will show you better, to what wonderful perfection the clock has now arrived. Sometimes, as you know, the state of the air is different to what it is at other times, that is to say, we may have storms about; we may have what weather-wise people call a high barometer or a low barometer. When you have a high barometer, so far as the clock is concerned, we may say that the air is thicker than it is at other times, and, therefore, the pendulum has more work to do in getting through this thicker air. Therefore, unless you take precautions, it will go more slowly. Now here is an arrangement which they have at Greenwich Observatory for correcting that imperfection. It is very beautiful and simple. There is the bottom of a compensating pendulum, and it swings over a magnet. This magnet makes the clock go faster the nearer it is to the pendulum, because there is another little magnet on the pendulum itself. If on account of the thickness of the air the pendulum is inclined to go more slowly, and, therefore, to make the clock go more slowly, an arrangement is made by a barometer which alters the position of that magnet, and the thicker the air gets, the nearer this magnet is made to work to the pendulum; the more it attracts it, and the quicker the pendulum swings. That is all I am going to tell you about the mechanism of clocks.

Now, there is another very perfect time keeper besides the clock, and that is the chronometer; and I will show you, as briefly as may be, an arrangement which enables a chronometer, when it is perfectly made, to be almost as good a time keeper as a clock, and mind you that is saying a good deal; because a clock is a thing which is fixed with great care to a wall, it never moves, it is always perfectly rigid, and with the best clocks precautions are taken to keep the temperature of the room in which the clock is as nearly the same as possible, whereas chronometers go all over the world, in hot climates, and in cold climates, and the more the temperature changes the more your chronometer ought to be accurate, on account of the danger which may come to a ship which does not know what the right time is. Now, the arrangement of a chronometer is different to that of a clock. You cannot, of course, have a pendulum in a little chronometer or watch, for after all a chronometer is only a big watch, but we have this seesaw arrangement, such as a pendulum supplies in a clock, brought about in a chronometer by a wheel with a spring. The mainspring of the chronometer makes the balance-wheel go one way, and then when the wheel is free to go back if it likes, this balance spring makes it go back. You want it so arranged then that this wheel shall first get an impulse from the mainspring of the watch, and then, after a certain interval, it shall be perfectly free to go back without having anything to do—without being controlled by the mainspring, so that it may be able to swing back in consequence of the elasticity of the balance spring. [The action of a chronometer escapement was then illustrated and described by means of models.] These then are the two chief escapements which

put us who live now-a-days in the position of having a clock almost as accurate and as perfect as you can imagine a clock to be, and not only a clock with a long pendulum fastened up in a stable position, but a chronometer without a pendulum at all, which may be taken to any part of the world, and be thoroughly depended on.

Then what have we done with these clocks and watches? We have established what we call a Civil time, that is a time useful for the ordinary purposes of life, which is shown by our ordinary clocks. On that wall, for instance, is a clock showing civil time, 24 minutes past 7. That time begins twice as it were, in what we call the 24 hours; it begins at midnight, and it begins at noon. In addition to that, we have Astronomical time, which begins at noon, and goes on through the 24 hours till noon again, so that 11 o'clock in the morning civil time is 23 o'clock astronomical time of the day before. Now the reason I suppose that I am talking to you now, on New Year's-eve—when it is too bad of the Society of Arts to have anybody lecturing or being lectured to—is that on this particular New Year's-eve a very wonderful thing is going to happen in connection with time, which will be remembered down the centuries. At midnight to-night, one of the assistants at Greenwich Observatory will go and put back that wonderful clock, which I hope many of you have seen, showing the astronomical time at Greenwich, beginning at noon, and going through the 24 hours to noon again; he is going to put that clock back 12 hours, and in future Greenwich time, instead of beginning at noon, as astronomical time has hitherto done, will begin at midnight; so that you see, instead of having civil time going through its 12 hours, beginning at midnight and again at noon, and astronomical time *beginning at noon* and going through the 24 hours, we shall have a civil time as it was before, but astronomical time *beginning at midnight*, so that they will walk with equal pace—the astronomical hours and the civil hours—to 12 o'clock at noon; then civil time will begin again, 1, 2, and 3, in the afternoon, whilst astronomical time will go on 13, 14, and 15, so that in astronomical time I am talking to you at half-past 19 o'clock; whilst in civil time it is half-past 7 o'clock.

Now why is this change going to be made this New Year's-eve? What is the good of it? To answer this question, I want really to go to the bottom of the matter with regard to this clock business, in order that what I may have to say at the end of the next lecture will be perfectly intelligible to all; and those of you who know as much about the subject as I do, must bear with me while I try to go over some difficulties which some children, I believe, encounter. I was once a child who certainly encountered these difficulties, and therefore I want to begin at the beginning, and to be as precise and accurate, and as simple as I can. In order to understand what I shall have to say about the proposed time change, there are three or four fundamental points I want to make clear. The first is apparently a matter very remote from clocks, for I want to tell you that the earth is round. A great many of course know that, but I want you to be perfectly certain that the earth is round, like this globe on the table. How do we know it is round? I am sure many of you, if you have been down to Ramsgate or Margate, and have used your eyes, must have made yourselves perfectly sure that the earth is round, and nothing else, on account of the way in which distant ships appear to you, according as you look at them from the top of the cliff, or close to the water's edge, especially at low water, and I am going to see if can show you how this is accounted for. I have here a globe and a tiny ship, and I propose to let the ship go sailing round the globe which represents the world, and to show you, by means of the electric light, what happens just as the ship is near the edge of the globe, as seen from the lamp. When the ship is a long way off you see the top of the masts only, then, as she comes nearer to you, you see the topsail, then the mainsail, and after you have seen the mainsail you see the hull. If the ship is going away, you first lose the hull, then the mainsail, then the topsail, and then the topgallant sail, and so on. Now, if the earth were a flat surface, of course that would not happen; the thing that you would see last would be the biggest, whereas, as a matter of fact, what you see last is just a little tiny bit of the topmast, just the little main truck; and it is worth while, when you are at sea, big children and little, to get a good telescope and see how beautifully and regularly, even to the very main truck of the tallest man-of-war, the whole disappears, with the most wonderful order—one almost might say, majesty. There you have an experiment which any of you can make at the sea side.

This is not all. We can reason by analogy from other bodies. The sun is round, and,

therefore, if the earth is round, she is like the sun. The moon is round, and, therefore, if the earth is round, she is like the moon; and by the way, I have a very beautiful photograph here of the moon which I should like to show you. It will show you that all those fairy stories about the man in the moon are not quite so true as some of us would like to think. When you examine the moon with a powerful telescope, or when you see a photograph, you see that there really is not a man in the moon picking up sticks, and that that good-natured face which we all of us have seen in the moon so frequently is really dependent on the fact that some parts of the moon reflect very much less light than others, but on whatever part of the moon's disc, we look, whether the brighter one or the darker one, we find the surface all very rugged and covered with volcanic mountains. In addition to that, you can see when we photograph the moon it is a very round body indeed. Further, there are some celestial bodies which you cannot see with the naked eye as you can the sun and the moon; there is the planet Jupiter—which we can see very well with the telescope—and here are four drawings of it—that is also round. We have another drawing of Mars, and you see that that is also round. But sometimes Dame Nature makes an experiment for us, and she does that when we have what is called an eclipse of the moon. Supposing we call this electric lamp the sun, and this globe the earth, you all know that the moon goes round the earth; you all know that when the sun and the earth have the moon between them we have an eclipse of the sun, and when the moon and the sun have the earth between them we have an eclipse of the moon. This is the beautiful experiment which Nature makes, bearing exactly on what we are discussing, for when the earth throws its shadow in that way, and when the moon travels into it, you see the actual shadow of the earth thrown on the moon, and it has a circular boundary; it has not a triangular or square boundary, but a round boundary. Now, a thing which throws a round shadow must itself be round, more or less, and, therefore, you see in the eclipse of the moon Nature makes a beautiful experiment for us which shows that we need not depend on analogy at all, and reason that because the earth is like the sun, therefore, the earth is round, and we need not be dependent on those nice little observations about ships, but we have simply to see what the shape of the earth's shadow really is, and from that determine what the shape of the thing is which throws the shadow.

Well, then, we agree that the earth is round. I remember when I was much younger than I am now, I could not believe that the earth was round in spite of all this beautiful reasoning, because it seemed to land me in so many difficulties. I had a globe, I remember, not unlike this one, and I used to say—Well, if the earth is round how comes it that the people below do not fall off. You have had that sort of idea I daresay some of you—Why do not they fall off. If we suppose the earth to be like this globe, we can understand people being on the top, but we do not understand people living at the bottom feet upwards, and when we come to consider the globe more carefully, we find that a straight line from England, through the middle of the globe, brings us very nearly to New Zealand. Many of us have friends in New Zealand, and they do not fall off. Why do they not? The worst of it is this, that the children in New Zealand have exactly the same difficulty with regard to us. They cannot believe that there is such a country as Old England. They think that where England is placed nobody could stop on by any means, because what is top to them is bottom to us, and so on. Now I want to see if I cannot make some of you happier, if you have been at all bothered about this, by just making a simple experiment which will show you how it is that people do not fall off; how it is that with the earth there is no top, and no bottom. If you imagine that globe suspended in the middle of this Lecture Theatre—only you cannot see that it is suspended—for instance, to represent the earth, the position of everyone on that globe is defined by the fact that he is perfectly upright—he is in a line which, prolonged, would pass to the centre of the globe, and if that globe were absolutely hung in space, instead of being hung in this room, the stars would be all round it. Everybody would have stars over their head, not of course the same stars; but people having one set of stars over their head would be just as happy as the other people who had another set of stars, and would not think all the time they were at angles of 45° or 90° or 180° with regard to the other people living on the other side of the globe. Now, I have here a piece of soft iron with a round pole, and I want to throw an image of that piece of iron on the screen. Here is a tin tack. Suppose that to represent a boy; we will suppose that is a boy at the top of the globe,

who thinks that other people will fall off who are below him. If I try to put another tin tack at the bottom here it will fall off; but now, supposing I make this into a magnet, I hope to show you that now we shall be able to represent people sticking all round the world quite easily. On passing an electric current round the piece of soft iron we make it into a magnet, and then we may have a perfect ring of tin tacks all round. If you allow those to represent the young gentlemen and ladies in the northern and southern hemispheres, you will have a good notion of the reason why they do not tumble off. That is, practically, a little earth in one respect, for the earth possesses an attractive force which is called the attraction of gravitation, while in the case of the magnet we have a something which we call magnetism, therefore, it is perfectly fair for me, I think, to show you this experiment that if on and round the earth we have a force tending to the centre in exactly the same way as we have a force tending to the centre of this magnet at the present moment, that there really is no top and no bottom with regard to that body, any more than there is any top or bottom with regard to this magnet. If I disconnect the electric current, so that the globe ceases to be a magnet, you see all the tin tacks tumble down at once. I hope nothing like that is going to happen to the earth; if it did, what I have said would be all nonsense, but if no such catastrophe happens, that will give you some idea why people do not fall off the earth. Every person you see imagines himself at the top, and that is the reason when you learn the use of the globe at school, the first thing you have to do, or almost the first thing, is to rectify it. It is a stupid word to use, but it means that, to begin with at all events, you have to bring the place you live at to the top of the globe. We bring England at the top of the globe. The people in Australia would turn it over, and have Australia at the top, so that you see so far as the globe is concerned, there is no top and no bottom, because everyone imagines himself at the top. The reason people do not fall off, is because from above, from the stars down to the centre of the earth, everywhere there is a force which tends to keep people on the earth.

Now another thing I have to tell you is that the earth is very big, and that is the reason you do not see the earth obviously sloping down away from you when at Ramsgate or Margate; what you do see is the horizon, and the only indication of the slope, such as you see on the globe, is just that slope which I pictured to you on the screen, which allows the hull of a ship to disappear before the topmast.

Now, the next important point that I have to bring before you is that the earth spins like a top. Here is a top, and you see as it spins it turns round a line, and the top moves very much less at the top and bottom than it does at the centre. If there were a fly for instance on the top or bottom, and another in the middle, the middle fly would have to go very much farther round every time than the fly near the top or bottom. Now, let me call the top and bottom the poles of the top. Let me imagine that there is a sort of skewer going from the top to the bottom, and that we call the axis. Now pass to the globe, which you see also has the power of rotating as the top has. This bit which scarcely moves at all is called the North Pole, and this the South Pole, and the part which moves most quickly where the fly would travel round the furthest in a given time, we call the Equator. So that you see after all when we say the earth spins, rotates or turns on its axis, we simply mean that it is very like a humming top, and that like a humming top it has two poles, an imaginary axis joining those two poles and an equator. Here is the same model I had before, but there is some clockwork inside it to make it turn round, and I have a magnet put in the globe from one point of the equator to the opposite one. When the clockwork is set in motion, you see the rotation of the earth, and at each end of the magnet there is something to represent a young gentleman at one end, and a young lady at the other, and they remain perfectly upright whatever position they occupy on the globe. So that what is top to one in one period of the earth's rotation, is bottom to the same person at another period of the earth's rotation.

I hope we have now got rid of one difficulty; but there is another smaller one. How is it we are not whirled off by this spinning, because, remembering how big the earth is, the rate of rotation will be considerable. The diameter of the earth is practically 8,000 miles, so that in one rotation of the earth a person at the Equator would be travelling through 24,000 miles. When we come to discuss the exact rate at which the earth spins, we shall find that it carries the person represented on the middle faster than

any ordinary railway train; but the reason we are not whirled off is that the air, the height of which we do not know, is carried round with us; it is, so to speak, connected with the earth to which we are fixed, and acts, as it were, as a sort of jelly. We may imagine all of us to be immersed in so much jelly, and it is this jelly—this stratum of air—which prevents us being whirled away. You know, for instance, if you are travelling in a railway train with the windows shut, you do not notice any wind; but if you are going by an express train against a hurricane, and put your head out of window you find a very different state of things outside. The earth instead of being brushed as it were by the rush of something outside it, as it rotates, really carries that something with it, and that prevents our suffering the horrible torture we should do if we were kicked off the world the moment we got on to it.

Now, there is another point. You say that the earth spins. How do you know that? Surely, it would be enough if the stars were to go round the earth. This globe is at rest, and suppose the earth is really at rest, and suppose this room, with all its pictures, were to go round the globe, the appearances to any boy or girl on that globe would be exactly the same. We know that the earth turns for this reason—a body at rest, and a body in motion have very different properties indeed. I will impart a very rapid motion to this body here, and I want you to see what happens. [An experiment was here shown with a gyroscope]. Here is another experiment by which the movement of the earth can be demonstrated much more accurately, though I have not time to go into it at any length. There is a pendulum hung from the ceiling, and when I set it in motion it will go backwards and forwards in a straight line. I will ask this young gentleman at the end of the table to notice the line the pendulum travels in backwards and forwards, and presently he will find that it has changed its position. The pendulum is arranged so that, practically, it is not connected with the earth at all, but the table is connected with the earth. The table will be carried round by the earth, while the pendulum will not be carried round, so that the table will change its place under the pendulum, and we know, as a matter of fact, how much that change will be, because experiments have been made in every part of the world; and this pendulum teaches us, if nothing else, that the earth rotates on its axis once in twenty-four hours, nearly. If this pendulum were swinging at the North Pole—as we know that the earth moves in the northern hemisphere from left to right, that is contrary to the hands of a watch, anybody could look down at it from above, the pendulum plane swing—will seem to move from right to left. But boys and girls in New Zealand naturally think of the earth's motion, as if they could look down upon it from above the South Pole. Their south is our north; so that in New Zealand, the earth, instead of appearing to move from left to right, appears to move from right to left; and, as a matter of fact, at the North Pole, and at the South Pole, the pendulum appears to be swinging two different ways, whilst at the Equator it swings neither one way or the other. The time of apparent change of swing plane, say through one degree, will vary from the Pole to the Equator in both hemispheres.

Miscellaneous.

GUTTA-PERCHA.

In the "Journal of the Straits Settlements Branch of the Royal Asiatic Society," for December, 1883 (Singapore, 1884), is an important communication from Sir Hugh Low, President of Pêrak, of a paper written by Mr. S. Wray, jun., on the above subject. The following is a *résumé* :—

*Getah Taban Merah** (*Dichopsis* [*Isonandra*] *gutta*). —This tree yields the best kind of gutta, and used to be plentiful in the jungles of the plains of Pêrak, stretching to a short distance up the hill sides. It seems to like considerable moisture, and will grow with its roots in a running stream. It is a tree of large size, attaining a diameter of from four to five feet, and a height of from 100 to 200 feet. It has large thin convex buttresses reaching six to eight feet up the stem, which is clean, straight, with a rich brown coloured bark $\frac{1}{3}$ to $\frac{1}{2}$ inch thick, peeling off in irregular pieces. The leaves are lanceolate in shape on the young tree, the mature ones being roundish oval with abruptly cuminate points; upper surface dark green, and the underside covered with minute silky warm brown hairs. The leaf, stalk, and young branches are also hairy, giving the whole tree

* *Taban*, the name of a tree; *merah*, red.

a brownish tint from underneath. The calyx has six sepals, three superior and alternate, and covered with hair; corolla white with six petals; style simple, sometimes persistent; ovules six, only two or three of which mature. The small berry-like fruit, is covered with brown hairs, with soft and sweet flesh, and the seeds contain an oil which is highly esteemed for cooking purposes. The flowers appear in May, and the fruit ripens in June, forming a favourite food for monkeys and birds. The Malays state that a tree only fruits once in three or four years.

The gutta from this tree is at first milk white, changing to red on exposure. It is collected as follows:—A staging is built round the tree so as to allow of cutting down above the buttresses. A *beliong*, or small axe, is used for this purpose. V shaped rings, one inch broad and fifteen to eighteen inches apart, are then cut into the bark along the whole length of the trunk by means of a *parang* or heavy chopping knife. These cuts are soon filled with a white cream-like sap, which in half-an-hour separates, and may be rolled into balls and boiled. A tree 2 ft. in diameter, at 6 ft. from the ground, and 100 ft. high, yielded 2 lb. 5 oz. of fairly clean gutta, valued by a Malay dealer at $1·20 per catty, or 2s. 6d. per lb., or 7s. 6d. as the produce of the whole tree.

Getah Taban Sutra (Dichopsis sps.)*.—This tree is found on low hills, near banks of streams, and at an elevation of 500 to 600 ft. It has the same appearance as the former, but the leaves are smaller, the hairs on the underside being yellowish brown. The buttresses are smaller and concave, the bark dark brown, smooth, and showing oval depressions where the branches have fallen away. The gutta is of a pale reddish brown.

Getah Taban Puteh† (D. polyantha ?)— In appearance like *D. gutta*, but the leaves are larger. It is found on hills up to an elevation of 2,500 ft., and not met with in plains or lower than 1,800 ft. The sap is much more copious, and does not coagulate so quickly, is of a dirty white colour, and much higher softening point than other kinds; boiling water even does not thoroughly soften it, and salt is often added to expedite coagulation. This gutta is frequently adulterated with that obtained from the Jelutong tree *(Kayu Jelutong‡)*, and also from two or three Bassias. This mixture is made before coagulation has set in. A tree ten inches in diameter at four feet from the ground, yielded 2 lb. 11 oz. of fairly clean gutta.

Getah Taban Puteh (*var.*).—Differs from the above in having smaller leaves, and in the shape of the fruit, which is longer in proportion to the breadth. It is found on hills at an elevation of 2,300 ft.

Getah Taban Chayer§ (*Dichopsis sp.*).—This tree is found at an elevation of 600 ft., and attains a large size. The backs of the young leaves are of a golden brown colour, which, when full grown, changes to a silvery hue; the leaves are not pointed. The flowers are of a pale green, and appear in the middle of September. The gutta coagulates very slowly, has a lower softening point than *G. Taban Puteh*, is of a dirty white colour, and of good quality.

Getah Taban Simpor (*D. Maingayi ?*).—Has large dark green leaves, prominent veins at the back of the leaves, which are covered with coarse, silky, light brown hairs, the rest of the leaf but sparingly; the tree grows on hills at an elevation of about 2,300 ft. One measuring 17 in. diameter at 3 ft. from the ground, and 63 ft. to the first branches, gave 12 oz. of gutta, which, by the application of heat and stirring, coagulated in twenty-three hours after tapping.

Getah (*Dichopsis*).—Much like the foregoing, but the leaves are lighter green and not so hairy. The gutta flows and coagulates very slowly; when heated, becomes sticky, and remains so for some time after cooling.

Getah (*Dichopsis*).—Has large, glossy, dark green leaves, with rich chocolate-brown hairs on the underside. Grows on hills at 800 ft., but the gutta is so sparing as not to be worth collecting.

Getah Taban (*Dichopsis*).—Varieties of this are said to grow on Gûnong Miru, near Kuâla Kangsa, and said to yield good gutta.

Getah Sundik (*Payena Leerii*).—This tree grows in swampy places, near the coast, and even at the side of brackish waters. The leaves are small, shiny, and of a reddish tint when young. The flowers white and sweet, and are eaten by the Malays. It is very easily grown, fruits freely, and thrives well on swampy plains near the sea. The wood is hard, close-grained, and takes a good polish. A tree 2 ft. 8 in. in diameter, at 3 ft. from the ground, and $38\frac{1}{2}$ ft. to the first branch, yielded $6\frac{1}{2}$ oz. of gutta. Another variety like the above, but with leaves longer in proportion to breadth, is also found in swamps, but its yield of gutta is less.

Getah Gahru ? (*Bassia, sp.*).—This tree grows on hills to an elevation of 2,600 ft., and yields a white and hard gutta used for adulteration. The gutta of several other Bassias are used for the same purpose.

Kayu Jelutong (*Dyera, sp.*).—This tree is one of the loftiest in the jungle, and the wood is used by Chinese in the manufacture of coffins, it being white and soft. It yields a large quantity of white sap, which is used for mixing purposes.

Mr. Wray has sent botanical specimens and gutta obtained from some of these to the Gardens at Kew, Calcutta, and Ceylon.

The second portion of Mr. Wray's paper contains a proposed method of preparing gutta-percha so as to obviate the present wasteful method.

* *Sutra*, silky.
† *Puteh*, white.
‡ *Kayu*, wood; *Pokok*, tree. The Malays, however, prefer the former term for tree also.
§ *Chayer*, liquid.

General Notes.

Over-pressure in Schools. — The Sub-committee appointed in connection with the London School Boards to consider the question of "Over-pressure," have made their report, which contains a series of recommendations on—(1) home-lessons; (2) keeping in for lessons in cases of backward children; (3) Board inspection; (4) returns, &c., by teachers; (5) power of withholding children from examination, and from preparation for examination; (6) appointment of competent managers; (7) underfeeding and irregularity.

Patents in 1884.— The number of patents applied for during the year 1884, under the Act which came into force on the 1st January of that year, was 17,110. The largest number reached in any previous year was 6,241 in 1882. In 1883, the number slightly fell off, doubtless in consequence of many patentees preferring to wait for the reduction in fees effected by the new Act, though the number of 5,993 was reached, a number in excess of the year 1881 (5,751), and of any previous year. It may be added that no approach has yet been made to the average number of applications in America. The number of patents applied for in the States in 1883 was 33,073.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at Eight o'clock:—

The Following Dates have been Fixed:—

January 14.—"The Employment of Hydraulic Machinery in Engineering Workshops." By Ralph H. Tweddell, M.Inst.C.E. Sir Frederick Bramwell, F.R.S., Pres.Inst.C.E., Vice-President of the Society, will preside.

January 21.—"Labour and Wages in the United States." By D. Pidgeon. The Hon. J. R. Lowell, the American Minister, will preside.

January 28.—"The Influence of Civilisation upon Eyesight." By R. Brudenell Carter, F.R.C.S. R. J. Mann, M.D., F.R.C.S., will preside.

February 4.—"Education in Industrial Art." By Charles E. Leland.

February 11.—"Report of the Royal Commission on Metropolitan Sewage." By Captain Douglas Galton, C.B., F.R.S.

Dates to be Hereafter Fixed.

"The History and Manufacture of Playing Cards." By George Clulow.

"The Musical Scales of Various Nations." By A. J. Ellis, B.A., F.R.S.

"A Marine Laboratory as a means of Improving Sea Fisheries." By Prof. E. Ray Lankester, M.A., F.R.S.

"Recent Improvements in Coast Signals." By Sir J. N. Douglass.

"The Evolution of Machines." By Prof. H. S. Hele Shaw.

"The American Oil and Gas Fields." By Professor James Dewar, F.R.S.

"Past and Present Methods of Supplying Steam Boilers with Water." By W. D. Scott Moncrieff, M.Inst.C.E.

Indian Section.

Friday evenings at Eight o'clock.

January 23.—"The Agricultural Resources of India." By E. C. Buck, Secretary of the Government of India in Revenue and Agricultural Department.

February 20.—"The Teak Forests of India and the East, and our British Imports of Teak." By P. L. Simmonds. Colonel Michael, C.S.I., will preside.

March 6.—"The Trade between India and the East Coast of Africa." By Frederic Holmwood, British Consul at Zanzibar.

April 17.—"The Parsis and the Trade of Western India." By Jehangeer Dosabhoy Framjee.

May 8.—"The Ancient and Modern Methods of Treating Epidemics of Small-pox in Japan." By Robert Pringle, late Sanitary Department H.M. Bengal Army.

May 15.—

Foreign and Colonial Section.

Tuesday evenings at Eight o'clock.

January 27.—"With the British Association to the Canadian North-West." By Stephen Bourne.

February 24.—"A New Route to Victoria Nyanza, through Equatorial Africa." By Joseph Thomson.

The papers for the meetiugs of March 17, 31, April 28, and May 19, will be announced later on.

Applied Chemistry and Physics Section.

Thursday evenings at Eight o'clock.

February 12.—"Production of Ammonia from the Nitrogen of Minerals." By George Beilby.

February 26.—"Tempered Glass." By Dr. Frederick Siemens.

The papers for the meetings of March 12, April 23, 30, and May 14, will be announced later on.

The dates given above are subject to alteration.

Cantor Lectures.

Monday Evenings at Eight o'clock.

The Second Course will be on "Climate, and its relation to Health." By G. V. Poore, M.D.

LECTURE I. Jan. 12.—The chief constituents of Climate, Latitude, Heat, Light, Barometric Pressure.

LECTURE II. Jan. 19.—The effects of Soil, Drainage, and Vegetation upon Climate.

LECTURE III. Jan. 26.—The chief sources of Atmospheric Impurities, both Inorganic and Organic. Climatic Diseases and Climatic Health Resorts.

The Third Course will be on "The Distribution of Electricity." By Professor GEORGE FORBES. *Dates*—February 2, 9, 16.

The Fourth Course will be on "Artists' Colours." By J. M. THOMSON, F.R.S.E., F.C.S., Lecturer on Chemistry at King's College, London. *Dates* — February 20; March 2.

The Fifth Course will be on "Carving and Furniture." By J. HUNGERFORD POLLEN. *Dates*—March 9, 16, 23, and 30.

The Sixth Course will be on "Photography and the Spectroscope." By Captain W. DE W. ABNEY, R.E., F.R.S. *Dates*—April 20, 27.

The Seventh and concluding Course will be on "The Manufacture of Toilet Soaps." By C. R. ALDER WRIGHT, D.Sc., F.R.S., F.C.S. *Dates*—May 4, 11, 18.

HOWARD LECTURES.

Thursday evenings at Eight o'clock:—

The fourth lecture of the Special Course delivered under the Howard Trust, on "The Conversion of Heat into Useful Work," by W. ANDERSON, M.Inst.C.E., will be delivered on January 22; Lecture V. on January 29; and Lecture VI. on February 5.

ADMISSION TO MEETINGS.

Members have the right of attending all the Society's meetings and lectures. Special tickets are required for the Juvenile Lectures. Every member can admit *two* friends to the Ordinary and Lectural Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the members, but admission can also be obtained on the personal introduction of a member.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 12...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. G. V. Poore, "Climate, and its Relation to Health." (Lecture I.)

Inventors' Institute, Lonsdale-chambers, Chancery-lane, W.C., 8 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Dr. Rae, "The Great North-West of Canada, and its People."

TUESDAY, JAN. 13...Royal Institution, Albemarle-street, W., 3 p.m. Prof. H. N. Moseley, "Colonial Animals, their Structure and Life Histories." (Lecture I.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Inaugural Address of the President, Sir Frederick J. Bramwell.

Anthropological, 3, Hanover-square, W., 8 p.m. 1. Mr. Oldfield Thomas, "Account of a Collection of Human Skulls from Jervis Island, Torres Strait." 2. Mr. A. L. P. Cameron, "Notes on some Tribes of New South Wales."

Biblical Archæology, 9, Conduit-street, W., 8 p.m. Anniversary.

WEDNESDAY, JAN. 14...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Ralph H. Tweddell, "The Employment of Hydraulic Machinery in Engineering Workshops."

Geological, Burlington-house, W., 8 p.m. 1. Mr. J. J. H. Teall, "The Metamorphism of Dolerite into Hornblende-schist." 2. Captain F. W. Hutton, "Sketch of the Geology of New Zealand." 3. Mr. T. Mellard Reade, "The Drift Deposits of Colwyn Bay."

Graphic, University College, W.C., 8 p.m.

Microscopical, King's College, W.C., 8 p.m. 1. Mr. A. D. Michael, "Notes on the Life-history of some of the little known Tyroglyphidæ." 2. Mr. C. Thomas, "A New Species of Acnieta."

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

Obstetrical, 53, Berners-street, W., 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. General Meeting. Mr. G. R. Julian, "The Appropriate Ornamentation of Works in Iron."

THURSDAY, JAN. 15...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Sir J. D. Hooker and Professor Oliver, "Plants collected by Joseph Thomson in the Mountains of East Equatorial Africa." 2. Mr. J. G. Baker, "Flora of Madagascar." 3. Mr. H. N. Ridley, "Orchids of Madagascar." 4. Mr. D. Sharp, "Japanese Colydüæ."

Chemical, Burlington-house, W., 8 p.m.

London Institution, Finsbury-circus, E.C., 7 p.m. Professor C. Stewart, "Sketches of Marine Life." (Lecture II.)

Society for the Encouragement of Fine Arts, 8 p.m. Conversazione at the Galleries of the Royal Institute of Painters in Water-colours, Piccadilly.

Royal Institution, Albemarle-street, W., 3 p.m. Professor W. Dewar, "The New Chemistry." (Lecture I.)

Historical, 11, Chandos-street, W., 8 p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Special Lectures on "The Science and Practice of Hydro-Mechanics." (Lecture I.) Mr. John Evans, "Physiography."

Numismatic 4, St. Martin's-place, W., 7 p.m.

FRIDAY, JAN. 16...Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Prof. Tyndall, "Living Contagia."

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. F. Geere Howard, "Secondary Batteries."

New Shakspere, University College, W.C., 8 p.m. Mr. R. Boyle, "The Authorship of 'Henry VIII.'"

Journal of the Society of Arts.

No. 1,678. Vol. XXXIII.

FRIDAY, JANUARY 16, 1885.

All communications for the Society should be addressed to Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The first of the course of lectures on "Climate in its Relation to Health," was given on Monday evening, 12th inst., by Dr. G. V. Poore. The lecturer began by directing attention to the chemical composition of the atmosphere, and its comparatively slight variation in different localities. The composition of the air in dwellings and in crowded rooms showed, no doubt, a degree of impurity which was often considerable, but the composition of the open air was, for practicable purposes, everywhere identical, and it was not probable that the slight variations in the proportions of the component gases which had been observed could have any recognisable effect upon health. The watery vapour present in the air, and its great importance in moderating extremes of temperature, and its relation to rain, dew, or fog, was fully discussed. Humidity of the air affected our sense of well-being very materially, and, indirectly, the dryness or moistness of the air had, doubtless, a great influence on health, because of the power of dry air to check, and of moist air to foster, the process of putrefaction, which had such an important indirect connection with many forms of zymotic disease. The causes of the great variations in the temperature of different localities was discussed at length, and the effect of various collateral circumstances in moderating the sun's influence, and in lessening the extremes of cold, were explained. A healthy man seemed to be capable of withstanding the extremes of temperature, and it was doubtful whether a large proportion of cases of sunstroke were not encouraged by dietetic or hygienic errors. High temperature was harmful by favouring putrefactive processes. How well men could withstand the extremes of cold, if properly fed, was shown by the remarkable health enjoyed by the crew of the *Eira*, during ten months which they spent in Franz Josef Land in the latitude of 80° N. These men were well fed, and consequently did not suffer from scurvy. Close confinement, small cubic space, an amount of cold often reaching to 65 degrees of frost, and a night of some months' duration, did not effect the health of these twenty-five men, who were one and all in rude health when picked up by Sir Allen Young. Such a fact as this, and the good health enjoyed by our troops in the Soudan, seemed to show that extremes of temperature, *per se*, had of necessity very little injurious effect upon health. The lectures will be printed in the *Journal* during the summer recess.

SOCIETY OF ARTS' PRIZES.

The Council of the Society of Arts are prepared to award the following Gold Medals in connection with the International Inventions Exhibition :—

John Stock Prize.

Under the John Stock Trust, one Gold Medal, for the best application of Photography to a Permanent Printing Process, Group XXVI., Class 140; Group XXIX., Class 159.

Howard Prizes.

Under the Howard Trust, five Gold Medals, for the best exhibits (coming within the terms of the Trust*) in the following Classes :—One for the best exhibit in Group IV., "Prime Movers," Class 26. Steam - engines and Boilers. One for the best exhibit in Group IV., Class 27. Gas and Air Engines. One for the best exhibit in Group IV., Class 28. Means of Utilising Natural Forces. One for the best exhibit in Group XI., Classes 59 to 62. One for the best exhibit in Group XIII., "Electricity," Class 72. Distribution and Utilisation of Power.

Fothergill Prize.

Under the Fothergill Trust, one Gold Medal for the most novel and best exhibit in Group

* The Trust was left "for the purpose of presenting periodically a prize or medal to the author of a treatise on the properties of steam generally, or any of them particularly, as applied to motive-power, or it may be of air or permanent gases, or vapours, or other agents so applied, or to the inventor of some new and valuable process relating thereto."

XXVIII., "Philosophical Instruments and Apparatus," Classes 148 to 158.

ALFRED DAVIS PRIZE.

Under the Alfred Davis Trust, three Gold Medals to be awarded in Division II. of the Exhibition (Music), Groups XXXII. to XXXIV., Classes 166 to 180.

The Council propose to ask the Juries in each Class to recommend for their consideration either two or three exhibits which they might consider deserving a prize. It will not be necessary for any special application to be made in respect of these Prizes.

A full list of the contents of the classes referred to above was given in the last number of the *Journal.*

Proceedings of the Society.

JUVENILE LECTURES.

UNIVERSAL TIME: OUR FUTURE CLOCKS AND WATCHES.

BY J. NORMAN LOCKYER, F.R.S.

Delivered Wednesday, January 7th, 1885.

At the end of the last lecture, on New Year's-eve, I brought before you a proof that it is the rotation of the earth—which really spins like a top—which causes the apparent motion of the stars, and that it is not the stars themselves going round the earth which accounts for their apparent movements when we look at the heavens, either at sunset or sunrise, or any time of the night. You remember the proof was that we had a pendulum which is heavy enough, and fond enough of doing its work in its own way, to remain in the swing-plane in which it was started. We had taken precautions, which I had not time then to bring to your notice, to let the pendulum hang and swing in such a way that it was perfectly free to go whichever way it wanted to go, supposing it wanted to go any way. In other words, therefore, it was perfectly uncontrolled by the movement of the earth, whereas below the pendulum we had a table which was by no means free to go where it liked. It was held firmly to the floor, and the floor is held firmly to the house, and the house is soundly built, so that perforce the table was obliged to move with the earth. The great point we got out was that the earth really rotates, and in a period of about twenty-four hours.

Now, there are two or three things I want to say a word about before we pass from that point. Let us suppose that this globe which is going round represents the earth. We will throw the electric light on to it. We have our little figures again, which I will put on the magnets as before, and I want you to notice—assuming that the electric light represents the sun—that once in each rotation of this globe each little figure will catch the sun just over the edge of the earth between it and the lamp; it will then come round until at last it gets to the other side of the part turned to the sun—and then it will be carried on until, a little time afterwards, the figure will lose sight of the lamp, or little sun, altogether —the sun will appear to set—and find itself on the dark side of the earth, where, of course, it cannot get any light at all from the sun. Here, then, we have sunrise for one figure and sunset for the other. In that way we have, as the first result of this spinning of the earth, the phenonema of day and night.

Now, there is another point I want to tell you about in connection with that. Of course we all know there is an enormous difference between day and night, but what is the origin of that difference. In the last lecture we had a little globe suspended in the middle of the hall, which we supposed to be surrounded by stars. Why, then, if the globe is surrounded by stars, is it that there is such a tremendous difference between day and night? The difference is just this, that the sun, which is a star, although it is not a very large one, is awfully close to us, practically speaking; it is only 92,000,000 of miles away, whereas all the other stars are at a very much greater distance, and, being this long distance away from us, they cannot give us so much light as the sun does. The sun being close to us, although it is a smaller star than many of them, gives us a good amount of light, just as a candle or lamp gives us a great deal of light if we put our book close to it; and it is because the sun is close to us, and gives so much light, that there is this tremendous difference between day and night. Some little children imagine that the stars are born every night, but that is not true. The stars are always there, although we cannot see them during the day, because the sun is so much more brilliant. I will make an experiment which will explain this to you. Here we have a board in which we have a con-

stellation, which I dare say you have seen before, giving us the appearance of the seven stars. Those stars seem rather bright when the theatre is dark, but when I have the gas and electric light turned on, taking you in fact from midnight to mid-day, you will find that when the eye is flooded with the light which we get from the electric light and the gas, those stars will grow almost as dim as stars do in the day-time, in fact you will probably not see them at all [turning on the light.] You cannot see them now, but on turning the light down you see they are still there.

This is just what happens every daytime. Our artificial sun treats these artificial stars very much as the natural sun treats the natural stars. You all understand, then, that this rotating of the earth produces the appearance of sunrise and sunset; the putting out of the stars when the sun begins to fill our eyes with stronger light, and the coming out of the stars when the sun apparently sinks behind the globe. Really, it is the globe turning round from the sun which brings about the state of things in which our eyes are not filled with such bright light, and, therefore, the little stars begin to twinkle again.

Now, I said the day was about twenty-four hours long, but, of course, astronomers must not be content to say a day is *about* twenty-four hours long; that will not do, especially as we have these very beautiful and accurate clocks now-a-days; therefore I propose next to show you how the astronomer utilises this spinning of the earth for the purpose of getting the true time. For that purpose he gets a telescope, which is called a transit instrument, and he fixes it so that it swings along a circle which passes from the north pole to the south, in a plane which passes through the centre of the earth, and through the place of observation, so that he can, by moving the telescope, notice when each star is exactly on the line joining the points I have named. I have a slide here which will show you how he does that. The cross wire in the telescope marks the middle of the field in view, and as we move the telescope from the north overhead to the south, that cross wire really draws a line along the heavens from the north pole to the point overhead, and towards the south, and it is to this central cross wire that the movements are referred. This diagram represents very much what you see at twilight. We will move the stars a little, so that you see one of them crossing the central wire; they are all moving very slowly, and you see one has now reached the central cross-wire. The astronomer notices the exact time at which that happens, and he says that star is crossing the meridian. At Greenwich, in the transit instrument there, when the star crosses the central wire, they say the star crosses the meridian of Greenwich; at Paris, it crosses the meridian of Paris; at Washington, the meridian of Washington, and so on; and if it were the sun instead of a star, we should note the time when the centre of the sun passed that central wire, and then we shall say the sun was passing the meridian of Greenwich, of Paris, or Washington, as the case may be. As a matter of fact, the observations are made at all the wires and at both edges of the sun, but I have only told you what the astronomer tries to arrive at by means of these observations.

Well, now we know what the word meridian means, and there are some very important considerations to be borne in mind in regard to it. I told you that the stars were an awful distance away. What have we to do with that? We have this to do with it, that if the stars are very far away indeed, they will always seem to be in the same direction, where-ever we look at them from. Some of you may say—well the earth is always in the same place, although it is turning on its axis, spinning like a top. But this is not true, the earth is not always in the same place, it travels round the sun while this spinning which I have demonstrated to you goes on; but although the earth goes round on its axis once in a day, and gives us, therefore, the day and night in twenty-four hours, it takes a whole year for it to go round the sun. We can prove most decidedly that it goes round the sun just as we can prove that it spins like a top, but I have not time to show you how that is done to-night. I have here several small globes representing the earth in different positions of its orbit round the sun; owing to the want of space, they have been placed in a very flattened circle, but in reality the path of the earth round the sun is very nearly a circle. Now I want to show you how it is that the stars always appear in the same direction from whatever part of the earth's orbit they are viewed. I have from each globe a string stretched, and I want you to understand that they all really point to some place a long way off. You see in a moment that they do not point to anything in this room, or even to anything in the next street, but you can imagine, I think, that if they point to a spot, say in Edinburgh, they would be practically what we call parallel, that is to say, the strings would

have to be so very long, that the few yards they are apart here would be spread over 400 miles, so the difference in the distance between any two strings at one end of the table and at the other would be something so very small that we could not measure it. Practically, therefore, they would be parallel to each other, and if I were to look at St. Giles, Edinburgh, from the end of one string, or from the end of the other, I should see it in exactly the same direction, whereas, of course, if I looked at anything in the next room from these two points it would appear to be in a different direction altogether. Now, if that is so, see what happens. We suppose that these three globes represent the earth in its path after an interval of twenty-four hours ; the first representing the position to-day, the next to-morrow, and the next the day after. Now, with the transit instrument mounted on the globe, I can observe the same star after an interval of twenty-four hours. That is what astronomers do, and observatories exist to enable such observations to be made ; and the interval between the times when the same star crosses the meridian is called star or sidereal time, and there are clocks made expressly, so that from any one star being on the meridian on one particular night, to the next night there shall be an interval of exactly twenty-four sidereal hours intervening. Sidereal time, then, has to do with the stars, and is such that we have twenty-four sidereal hours from the transit of a star in the way you have seen on one night to the transit of the same star the next night. Now, you understand that when one part of the earth is having midnight, the opposite part is having midday. Here are two globes representing the earth in opposite positions in the orbit. From these two positions of the earth there are strings drawn going to the same star, and you can easily see that after six months we get the transit of the star at noon instead of midnight; that when we get the transit at one place at sunset, the same star would be visible at another place at sunrise, so that this star time would land us in very considerable difficulties, and 12 o'clock star time would mean every part of the day in succession. 12 o'clock star time would be night in one place, would be noon at another, and sunrise at another. It really comes to this. We must have something which has to do, not with the distant stars, but with the big star which is near us ; we must regulate our clocks with reference to the sun, so that when the sun is south at noon we may say, as we do, that it is 12 o'clock ; we must call the middle of the day the same hour and we must call the middle of the night the same hour all over the world. How inconvenient it is, for instance, when we go down to the seaside, not to have the tide wound up in that way. We have to make all our arrangements about bathing, and going round the rocks, and so on, and the tide varies every day. It would be much more convenient if we could have it high water the same time every morning. There is a case in point where we have a period which varies from that which regulates the usual requirements of our ordinary every day life. Now, what do we do with regard to star time. We use this star time to take us to something else, and what the star time takes us to is this. [The lecturer then illustrated by means of the model globe the fact that the earth has to make rather more than a revolution to complete the solar day.] You see then if we must have a time which depends on the sun, the near star instead of the remote ones, and if that time is to be twenty-four hours like the other ; the hours, the minutes, and the seconds must be longer, and as a matter of fact we have that time, and that is called mean civil time. It is so arranged that the twenty-four hours are reckoned from an average sun all the year round, so that, as near as may be, 12 o'clock means the middle of the day for every day in the year, with the sun to the south. Those hours, minutes, and seconds must be longer than the hours, minutes, and seconds of sidereal time, because the earth has not only to get back to the same place, and to be in the same position with regard to the star, but it has to go a little further to arrive at the same position with regard to the sun.

Now, as a matter of fact, this sun time does not represent the true motion of the true sun, and that is why it is called mean, or average sun time. The sun, for several reasons which I have not time to state, is not quite regular, or does not appear to us to be quite regular, so that if we take the time by the sun-dial, we find that the mean time varies from the sun-dial time, sometimes pretty considerably, the reason being that the movement of the earth round the sun is not quite uniform—the movement is not quite the same at different times of the year, and because the spinning of the earth is carried along in one plane, while the movement of the earth round the sun is carried on in another plane. Then, if we get twenty-four hours' sidereal time, and add three minutes, fifty

seconds sidereal time to it, we shall get the period which we call the mean solar day, on which mean solar time is based. I have here some diagrams which show how, by means of what is called the equation of time, we bring the time shown by the sun-dial in relation to the time shown by mean time clocks and used by the nautical almanacs, or ephemerides, as they are called, constructed by astronomers in the way I have mentioned.

Whenever, then, the mean sun comes to the meridian, we have the starting point, as it is now arranged, of the Astronomical day—o ·om· os·; whereas, as you know, with the Civil day we begin the order from one to twelve over again. Now round this model globe I have put twenty-four wafers, and as I have described what is known as mean time, I think you will all exactly understand what those wafers are for. If we light up the sun again, and this globe goes round, you will find the difference between the wafers is practically that part of the circumference of the earth at the equator which passes under the sun in an hour's time. If the globe takes twenty-four hours to go round, then, if one wafer is now exactly under the sun, in an hour's time the next wafer will be under it, and in another hour's time the next one, and so on. Now this brings us to a fact which it took many a long year to find out, although it seems very obvious to you when I mention it. At any one instant the time is different at different parts of the world. Pliny, in his "Natural History," remarks with satisfaction upon what had been noticed when the various signal fires were lit along the whole coast of the Mediterranean from east to west; these were lit on the approach of the enemy, sometimes even in the middle of the day, when they were visible in consequence of their smoke, not by their light. These signal fires were visible at different times in different places, the time decreasing in one direction and increasing in another, and from that, and other observations, the ancients got the idea which is very clear to us, that time is not always the same at different places in the world. It will be midnight in one place when it will be midday in another. At first this looks a little awkward, because, supposing each wafer there represents an important place on the earth's surface, you will require 24 different times; call one place London, we have Greenwich time there, which is practically London time; suppose the next represents Paris, then we have Paris time, and it is quite right, of course, for the people who use this mean solar time to divide the time by reference to the sun for their own special use, and, as a matter of fact, all countries have now what they call local mean time. But there are a great many other things for which time is necessary, for which local time is now used; for instance, let these wafers represent, one of them Paris, another London, another Berlin, and another Washington. They represent the capitals of four great nations. Those nations have ships that do not want to be run on rocks, and for the use of these ships they have to make maps for different parts of the world. Well, you may say, what has this to do with time? It has everything to do with it. On a map these time differences, which depend on how the places represented by these wafers are presented to the sun, are called differences of longitude, but they are simply differences of the time at which the different places come to the meridian one after the other; an hour's difference of time is represented by 15 degrees of longitude, and, that being so, you see the determination of longitude is a very simple matter indeed. I will show you how it is done, in order that you may see how very simple it is. When I was referring to the clock last week, I did not tell you, as I must now, of the recent application of electricity to the clock to enable very considerable accuracy to be secured in observations, greater accuracy than is possible by listening to the beat of the clock. You hear this clock ticking; at every beat of that clock, there is an electric current which starts from the pendulum, and makes a little puncture on this revolving barrel of paper, and you can quite understand that if I were to make that paper very large, the barrel very big, the interval which elapses between each beat of the pendulum would be represented by a very large space—a long strip of paper, which I might divide into 100, or even 1,000, parts, and in that way I should be able to divide a second of time into 1,000 parts. Supposing a man at one of these wafers has a clock connected with this revolving cylinder, which is called a chronograph, and he determines with an observer at any other wafer to give him a signa when a star cross his meridian. This clock is giving its tick every second, and quite independently of where the observations are made, whether at one wafer or another. The observer, when he sees the star or sun crossing the meridian, by means of the electric current; makes a mark on the sheet of paper, and he can, a month afterwards if necessary, ascertain

the exact moment at which he gave that tick. When the star comes to the meridian of the next wafer, the next observer gives a tick in the same way, and then you have only to count the number of seconds on this cylinder which have elapsed between those two imprints to determine the difference of time between the two places. You may imagine, for a moment, that electricity has taken no time to do this, and then you can get the time which the sun has taken to cross the space between any two wafers. You see, then, that there is a most interesting connection between ships and the maps that are necessary for their navigation, and the earth's rotation. At present, we have a great many nations in the world with navies, and they all make maps; and one says, with regard to these wafers, We will make the start of longitude—our prime meridian—the cross wire in the transit instrument of our chief observatory; another says, We will not start from your prime meridian—we will have one of our own. Another nation will not adopt either of the two former ones, and, therefore, starts one of its own; and in that way we have many different maps—French, English, German, and so on—not agreeing among themselves in the longitude, although they agree very well in the latitude. [Some of the red wafers were here distinguished by white wafers to denote prime meridians.] Here I have an English map and a French map, which will show you how the meridians which we get on the most familiar parts of the country make it look quite different, according as the map comes from an English or French source. On an English map the first meridian runs through Greenwich, but in the next map, which is a French one, it is changed altogether; the meridian no longer runs through Greenwich, but through Paris; and so with German maps, and so on. Now, it is a remarkable fact that we are now rather worse off in this matter of different longitudes than we have ever been since the world began. If any of you care, and have the leisure to look at any old book, and to learn the history of geography, and how the first maps were made, and who made them, you will find that the men of old, such as Strabo and Ptolemy, had no notion that the first meridian ought to be placed where they lived, but that its right place was at the beginning of things; and, therefore, the differences of longitude in the early maps depended on the increased knowledge as to the beginning of things. At the time when the first maps were made, when people began to get the idea of longitude, the point on earth which was supposed to be most outside everything, the most to the west, was Cape St. Vincent, which they called "Promontorium sacrum," and it is a very curious thing that the meridian which was drawn from that place for a very long time passed very near Greenwich. That of course was a mistake. Afterwards travellers sailed down the coast of Africa, and discovered the Canary Islands, where were the gardens of the Hesperides, and which were at first called the Fortunate Islands. They thought that was the most westerly bit of land. They wanted the longitude to run from left to right, and so they changed the meridian to the Fortunate Islands, and that was, practically, all they did. The Alexandrians did not have a meridian for Alexandria, and the Greeks for Greece, and the Romans for Italy, and so on; such an idea never struck them, but it has struck us, for with the increased necessity of these maps has come increased accuracy of observation, and that increased observation is at its very acme in the observatories of the great capitals, and therefore, each nation has determined to deal with a thing on which they can most rely, so that the cross-wire in the telescope at Greenwich is the starting point for English longitude; at Paris, for the French; at Washington for the American longitude, and so on.

But, although it is necessary to have local time, we can imagine a condition of things in which one set of maps ought to do for all the people in the world. There is another consideration; you have a telegram come from a place five wafers to the right, which is a difference of five hours, and another coming from a place five wafers to the left. These two telegrams, if they come to you at the same time, will have ten hours difference of time on them. If it is 12 o'clock with you, one telegram will have been despatched at 7 o'clock in the morning at the place it was sent from, and the other at 5 o'clock in the evening from the place it was sent from, and, as the Americans say, you will be a little mixed to know at what hour of your time these telegrams left their respective places. Again, comets are sometimes discovered, and if you have only one time for all the world, you may telegraph all over the world that a comet has been discovered at a certain time at a certain place; but if from one wafer you telegraph the comet has been discovered at such a time, and from another wafer it is telegraphed that a comet has been

discovered at another time, you will be again in uncertainty, and will not know the real time at which it was discovered until you have made a calculation, so that there is use for time beyond the uses of every day life, and there are uses for longitude besides the absolute necessity of knowing how many miles it is from place to place.

These difficulties and others like them have been growing for years, until at length, last year, there was a meeting of wise men at Washington, and I am going to conclude my lectures by referring to the conclusions at which these wise men arrived, and, if I have done my duty, I do not think you will have any difficulty in understanding what they did, or the very great interest which attaches to it. The first resolution was the adoption of the meridian passing through the centre of the transit instrument at the Observatory at Greenwich as the initial meridian for longitude. If what these wise men want is carried out, we can simply abolish all these white wafers except one. Now, to go a little further, it was resolved that from this initial meridian longitude should be counted in two directions up to 180°. That is to say, this being the initial meridian, we reckon longitude right and left. I may tell you, that I believe the reason that was done was that although a great many astronomers believe it would be better for the longitude to go all the way round in the same way as the twenty-four hours go on the dial, still, if it had gone eastwards, that would have altered all the longitudes in America, and all the meridians which divide their states and territories would have required to have their names changed; on the contrary, if it had gone westward, all the longitudes on the maps of those people in Europe who have accepted the meridian of Greenwich must have also been changed; 1 hour would have been 23, 2 hours would be 22, and so on.

The next proposal was that there should be a universal day for all purposes for which it may be found convenient, not interfering, of course, with the use of local time for local purposes.

You see how beautifully connected the initial longitude and the initial meridian are with the purposes of this universal time. You have simply to take the time of this one meridian instead of taking the time of all the twenty-four meridians, and in that way you regulate the whole planet by considering what time it is at one point on its surface.

The next resolution was that the universal day should be a mean solar day. You understand what it means—not a sidereal day but a solar day, and that it should begin for all the world at the moment of mean midnight at the initial meridian, and it is to be counted from zero up to twenty-four hours.

It is that which is going to alter all our clocks and watches.

I have already told you more than once that civil time practically begins twice in the day, once at midnight, and again at midday, but that astronomical time begins only once in the day, and that at noon. The Conference says, No, the astronomical time is not to begin with the second batch, so to speak, the second twelve hours of civil time, so that 23 hours 59 minutes will no longer mean one minute to noon, but one minute to midnight. So the Conference expressed a hope that, as soon as may be practicable, the astronomical and nautical days will be arranged so as to begin at mean midnight.

Those are the chief resolutions. Now, having 24 hours, means that our clocks and watches, which only show 12 hours, will require to have something done to them. Some people say, "Oh, this will not come in our time. It is a thing which is all very well for astronomers, people who look at comets and such outlandish things, but we shall not want it." But I think you will want it, for the reason that it is so very convenient. What will happen is this, all the telegraph offices in the world, or a great number of them, are under English control, and if the English Government accept the suggestions of this Conference, you may depend upon it that the English telegraph companies will find the comfort of having only one time to keep. A hundred different times all over the world means all sorts of difficulty with regard to the registration of dates and hours. You can understand that if you have fifty different kinds of registration in different places changed into one registration you have a great gain. The registration of time is just like the registration of a parcel, if you can have one standpoint to deal with instead of fifty, so much the better. Receivers of telegrams will be delighted, because if I know for instance that it is 12 o'clock when I get a telegram sent to me from Calcutta, and that it was sent out at a quarter to 6 p.m., I do not know how long it has been coming, without taking some trouble. I have to ascertain what is the difference in longitude between the two places, and probably I do not take the

trouble to find out any more about it; but if there is one universal time, all that difficulty will be avoided. That is one very good reason why the telegraph companies will take it up. Then the telegraph companies are very closely associated with the railway companies. All of you either have or will have to take long journies on the Continent some time, and having to go at short notice you will find yourself in the most fearful muddle between a.m. and p.m. You will not believe it is possible to make so many mistakes. If you want to go to Vienna, you leave London, say, at 7 o'clock at night, but when you look at the time tables of the continental trains you have an immense trouble to find whether it is in the morning or in the evening that you will arrive there. Now, if 7 in the evening were 19 o'clock, there would be no difficulty whatever in discriminating, as there is now between a.m. and p.m. All the important railways will take it up, as they have done in America. In America it used to take six or seven days to get across the continent; you go through a great many degrees of longitude there, and you have to change the time of your watches every day exactly the same as you have to do at sea, because you must be perfectly accurate with railway time. In America they at present use the Greenwich meridian, and keep their clocks to Greenwich time, minus so many hours difference of longitude, and they show twenty-four hours on their dials. In England this consideration is not quite so important as it would be if the country were more extended in an easterly or westerly direction, but still it has many advantages about it, and it will be important for English railways to follow what they do in America and on the Continent, so that I have no doubt in time they will adopt the same method. If the railway companies and the telegraph companies adopt this time, we shall all of us have to do it.

Perhaps, in conclusion, I ought to say a word or two as to what may be considered the best plan for making the alteration. Putting twenty-four hours on the clock dial, such as you see there, and especially on a watch dial, will not do. Undoubtedly the proper way is to have two sets of twelve hours, and there are two or three ways of bringing that about. Messrs. Dent, of the Strand, who have been so kind as to send that clock for you to see to-night, and who have rendered me invaluable help in this question with regard to watch dials, have before them two or three suggestions, and Mr. Trueman Wood has shown me another this evening. The obvious suggestion is, dealing with watches, to have two rows of figures—an inside row of twelve hours, and outside row of twelve, and the outside row might either mean afternoon, or before noon, as you like. In America, they do it rather differently, they make an inner circle of figures and an outer circle, changing over at bottom, so that the inner circle represents the hours between sunrise and sunset, that is the average hours, whereas the outside figures represent the hours of the night, so that you get 12 o'clock at midnight represented at the top of one, and 12 o'clock in the day represented in the other. A great many people, however, consider this changing over a very brain-splitting contrivance, and I am rather inclined to agree with them. Another suggestion is that if you must change your dial and must have twenty-four hours, it is best to have only one hour visible at a time, and so there are two or three suggestions of peep holes; that you should have a wheel with the twenty-four hours inside the watch, and at the beginning of every hour you will see at this little peep-hole what hour it is, but the objection to that is that you would have to look at it, whereas in looking at a watch, you do not so much examine the figures as look at the conformation of the hands, that is, the way in which one hand lies with regard to the other. You do not see that one is on the point of three minutes and another a little before 8 o'clock, but it is the general appearance of the hands which tells you in a moment what time it is. That is the reason that on a great many large clock dials you do not now have any figures at all, but little flowers, as in that latest clock in London, the City and Guilds Institute, at Princes-gate. Here is an arrangement by which the clock every twelve hours shifts the series of twelve hours—1 to 12, to 13, to 24, but there you do not get much advantage, because you may have that information outside the usual dial. But whatever happens with regard to this matter, no doubt it will be discussed very much during the next few months.

I do not think anyone will agree to have clocks striking twenty-four hours. The desperate condition of a man who wants to know whether it is 23 or 24 o'clock just as he is going home is a thing one cannot well dwell upon; striking twelve is quite as much as is needful. I believe the continental system, which is very much in use in Rome, of striking

only six hours, is quite enough even for village people, who are more dependent on the hours of the night than people who dwell in towns.

That is all, I think, I need bring before you with regard to the resolutions of the Conference. I hope I have shown you that the matter is not without interest and not without importance, and when the Society of Arts asked me to give these lectures I thought, probably, it might be useful to some of the younger ones among you to be able to follow, with a little more familiarity and knowledge than you would otherwise have done, the discussion which is sure to be going on in the newspapers and amongst scientific men for the next twelve months, with regard to the new Universal Time.

Dr. MANN then proposed a vote of thanks to Mr. Norman Lockyer for his very able and interesting lectures, which was carried unanimously.

SIXTH ORDINARY MEETING.

Wednesday, January 14, 1885; Sir FREDERICK BRAMWELL, F.R.S., Pres. Inst.C.E., and member of the Council of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Barrett, William Lewis, 17, Steyne, Bognor.
Bousfield, William Robert, M.A., 4, Crown Office-row, Temple, E.C,
Cooper, Henry William Alexander, Pretoria, Transvaal, South Africa.
Dahl, Robert Hutchinson, Morden-lodge, Putney.
Duncan, William Henry, Coalbrookdale, Shropshire.
Garrod, Edwin, 22, Great George-street, Westminster, S.W.
Hirsch, Gustav, Wanderers' Club, Pall-mall, S.W.
Institute of British Carriage Manufacturers (Secretary), 16A, Great Queen-st., Lincoln's-inn, W.C.
O'Donovan, Denis, Brisbane, Queensland.
Oliver, Robert Stewart, 19, Ness-bank, Inverness.
Orme, Robert, 29, Collingham-place, S.W.
Peacock, W. P., 51, Water-lane, E.C., and 22, Lower Tulse-hill, Brixton, S.W.
Priestman, John, 25, St. Charles's-square, Notting-hill, W.
Skinner, Richard, 6, Park-road, Bromley, Kent.
Turner, Barrow, 37 and 38, East-street, Manchester-square, W.
Wakefield, Henry Tyndale, Metropolitan Board of Works.
Webster, Miss, 3, Sydney-villas, Richmond, Surrey.

The following candidates were balloted for and duly elected members of the Society:—

Carswell, John George, 37, Victoria-road, Old Charlton, Kent.
Fisher, Alfred, School of Art, Gosport, Hants.
Gavey, John, Post-office Telegraphs, Cardiff.
Lopes, George, B.A., London, Brighton, and South Coast Railway, London-bridge, S.E.
Lynch, Edward James, 1, Becco des Cancellas, Rio de Janeiro.
Meade, Thomas de Courcy, Hornsey Local Board, Southwood-lane, Highgate, N.
Slagg, Charles, Presteign, Radnor.

The paper read was—

THE EMPLOYMENT OF HYDRAULIC MACHINERY (TWEDDELL'S SYSTEM) IN ENGINEERING WORKSHOPS.

By RALPH HART TWEDDELL, M.Inst.C.E.

So far as I am aware, this subject has not yet been discussed by our Society.

Our proceedings are, fortunately, enriched by an able series of Cantor Lectures, delivered by Professor John Perry, on "Hydraulic Machinery;" and assuming that most of you have studied these, it will not be necessary for me to occupy your time this evening in considering the theory of hydro-mechanics. Nor do I propose to weary you by entering into the details of construction of the various hydraulic machine tools now employed in engineering workshops.

I propose, at the conclusion of my remarks, to show you photographs of some of the machines themselves.

A brief retrospect of hydraulic schemes and machines imagined or designed in the past, will, I think, be interesting, and, to some extent, help to explain the subject of this paper.

"There is nothing new under the sun;" and the conclusion eventually forced upon us will, I think, be this, that had the engineers and philosophers of olden times possessed the mechanical appliances or tools necessary to carry their schemes into practical effect, there would not have been much room left for other more modern inventors.

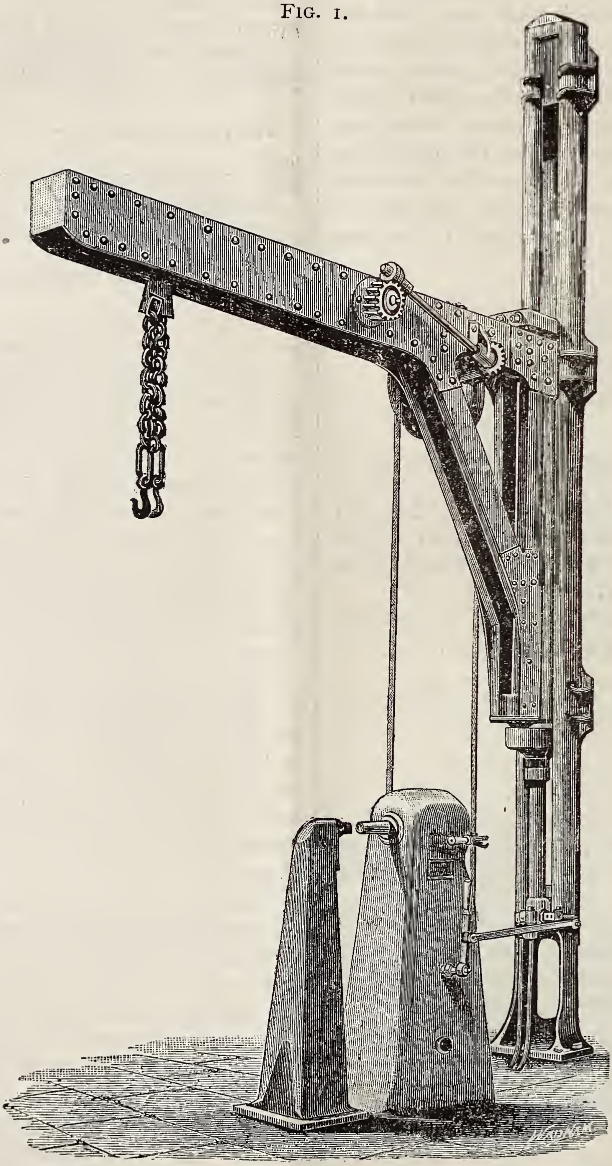
I do not propose to go back to the very earliest ages, but it would be unpardonable were I to omit the inevitable reference to Ctesibius, the inventor of the first "force" pump, and the tutor to Hero of Alexandria; the latter, in his writings, describes some of the inventors of the appliances referred to by him as "ancient philosophers;" so, if we add this indefinite period to the 2,000 years which have elapsed since Hero himself wrote, we

establish a fairly good claim to antiquity on behalf of hydro-mechanism.

Unfortunately, one of the earliest applications of hydraulic pressure to moving weights seems to have been of rather a fraudulent character, being employed by the heathen priests to open and shut the door of a temple, and as the means by which this was done were invisible to the worshippers, it was not difficult to attribute to them a divine origin.

Passing from this rather discreditable adaptation of hydraulic power, I may mention that much curious information of this kind can be found in Thomas Ewbank's work on "Hydraulics," and also in a pamphlet on "Hydraulic Machinery, Past and Present," by Professor Henry Adams.

Fig. 1.



Hydraulic Rivetter and Crane (Tweddell's System).

Coming now to about the sixteenth century, and passing by the descriptions and writings of the Marquis of Worcester as too vague for anything but a modern patent specification, we reach a most important period in the

history of our subject. This is the "distribution of water," when stored under a considerable head, to the various machines or places where it is required for use. I wish to impress upon you the words "considerable" head; it is necessary to note this, in order to distinguish this branch of engineering from that of "irrigation," and I mention this in order to prevent my claims on behalf of Ctesibius being triumphantly upset—by a reference, for example, to the bucket and lever pump of the early Egyptians, said to have been invented some 3,500 years ago. The vast quantity of interesting material at our disposal renders a mere selection very difficult, but I think we must, in fairness, canonise Ctesibius as the patron saint of what is generally understood by the term high-pressure hydraulic machinery, since without his invention of the force pump, it would be impossible to obtain an "artificial" head. One of the first practically to apply pumps to force water under an artificial head, with a view to the distribution of the power thus obtained, was Peter Maurice, who, so far back as 1582, erected a series of force pumps under the arches of London-bridge, and raised water to a height of 120 feet, or, say, 55 pounds pressure per square inch. The next important advance in pumping apparatus was that made by La Hire, a Frenchman, who invented the double acting pump; this was a decided advance, enabling, as it did, one cylinder do the work of two, by placing suction and delivery valves on both sides of the piston. Having thus referred to the force pump, which, when driven by a steam-engine or other prime mover, is the first element in any system of hydraulic transmission, we next come to the reservoir, tower, or accumulator, into which the water is pumped or forced, and there stored ready for distribution.

The simplest mode of obtaining a head or pressure of water, is to collect the rainfall and store it in a reservoir on the top or side of a hill, and thence convey the water, through pipes, to the lower level. Supposing that the water could not be thus collected, the alternative would be to pump it up from a lake or stream at the foot of the hill. This of course necessitates the use of a force pump; and as hills are not always available, the use of a high tower was next proposed. The employment of such towers, or reservoirs, in connection with a system of mains to distribute the water thus stored up, is well understood by everyone, and we shall see that the same principle is carried out in all high-pressure hydraulic machinery, so far as the transmission or distribution of the hydraulic power is concerned.

So far back as the 17th and 18th centuries, the use of such towers in Germany is described by Blainville, who, writing in 1705, says:—

"The towers which furnish water to this city (Augsburg) are also curious. . . . . . Mills, which go day and night by means of this current, work a great many pumps, which raise water in large leaden pipes to the highest stories in these towers. . . . . . One of these towers sends water to all the public fountains by smaller pipes, and the three others supply with water a thousand houses in the city."

In connection with the distribution of water, it is curious to note that, so far back as the middle of 16th century, the—

"Mayor of the city of Gloucester, with the Dean of the church there, were authorised to convey water in pipes of lead . . . . from a neighbouring hill, satisfying the owners of the ground for the digging thereof."

The Dean of Gloucester's application of hydraulic pressure compares favourably with that of the heathen priesthood already alluded to. It is evident, therefore, that the general principle of utilising a pressure of water, due to either a natural or artificial head was well understood some centuries ago.

The advantages due to transmitting power by water were also well appreciated by Bramah, and his patent, No. 3,611 (1812), is curious reading. He does not, however, err on the score of modesty, when he excuses a somewhat profuse recital, because of his patents' "claims to merit and superior utility compared with any other patent ever before sanctioned by the legislative authority of any nation." It is important, however, to note that with Bramah, the era of high working pressure commences, and in this same specification he mentions that he is in the daily habit of applying water without any difficulty, in his hydrostatic machinery, under a head of 20,000 feet. This, of course, refers only to the final pressure in his hydraulic presses, and is only, therefore, an momentary or intermittent high pressure.

The successful application and use of a continuous high-pressure of, say, 700 to 800 lbs. per square inch, is, however, due to Sir W. G. Armstrong; and it was to obtain such a pressure that, after using a tower (to use his own words) he had "to resort to another form of artificial head, which possesses the advantage of being applicable at

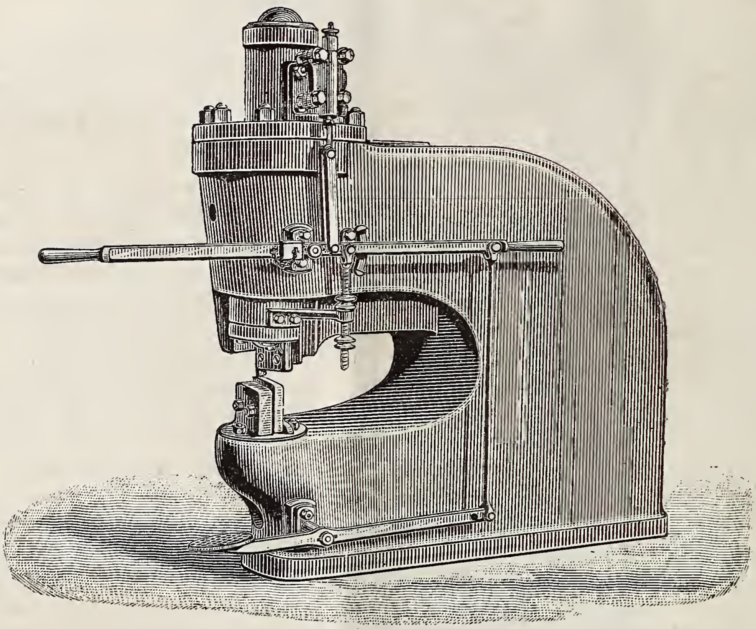
a moderate cost in all situations, and of lessening the size of pipes and cylinders by affording a pressure of greatly increased intensity." This he called an "accumulator," from the circumstance of its accumulating the power exerted by the engine in charging it. The accumulator is, in fact, "a reservoir, giving pressure by load instead of elevation, and its use, like every provision of the kind, is to equalise the duties of the engine in cases where the quantity of power to be supplied is subject to great and sudden fluctuations."

This system, as we all know, has now been applied almost universally to the working of the lifting machinery used in docks, railway goods yards, &c.

Bramah fully appreciated the field available for high-pressure hydraulic machinery, and not only does he refer to this in the above quoted patents, but in a letter written in 1802 (ten years before) he says:—

"I have now applied it (the hydraulic press) with the most surprising effect to every sort of crane for raising and lowering goods in and out of warehouses. So complete is the device, that I will arrange to erect a steam-engine in any part of Dublin, and from it convey motion or power to all the cranes on the quays or elsewhere. . . . This I do by the simple

Fig. 2.



Hydraulic Shearing Machine (Tweddell's System).

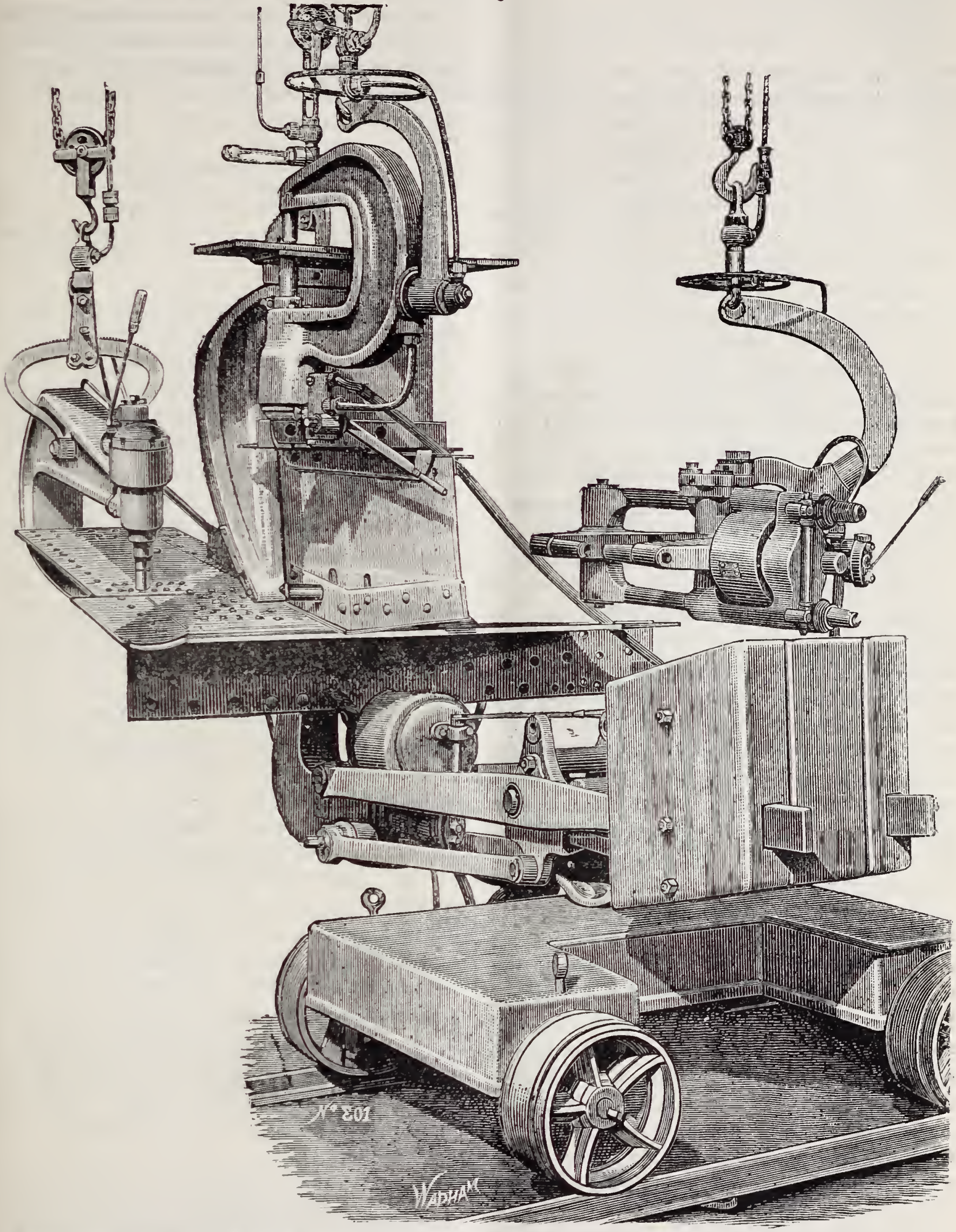
ommunication of a pipe, just the same as I should upply such premises with water."

Bramah never carried this scheme out on any considerable scale; but, in preparing this paper I came across a curious sentence in his patent of 1812, in which he says, "by such an 'accumulated' magazine of power, he is enabled to work machines for sawing, turning, planing and pressing, forging, stamping, &c.;" and, finally—I suppose by way of making a good broad claim—adds, "and for any purpose, known or unknown, whatsoever." So far as its application to lifting machines is concerned, Bramah's dreams of eighty years ago are the "facts" of to-day; and Mr. Ellington is now laying beneath the busiest streets of London itself hydraulic mains, distributing water at a pressure of 700 lbs. to 800 lbs. per square inch, and, by means of hydraulic lifts, making the much abused "top-floor back" as valuable, or more so, than the "first-floor front" for residential purposes. With the pumping and accumulator station in the city of London, the dweller using power therefrom in Belgravia can truly say with Bramah, "that it is im-

possible for any person, unacquainted with the principle, to discover how or where the power comes from." A similar mode of working was carried out in the town of Hull, by Mr. Henry Robinson, some ten years ago.

If, however, instead of hydraulic lifts, dock

FIG 3.



VARIOUS TYPES OF PORTABLE HYDRAULIC RIVETTING MACHINES (TWEDDELL'S SYSTEM) APPLIED TO SHIPWORK.

gates, engine, capstans, or crane, you imagine this hydraulic power applied to drive punching, shearing, flanging, forging, or rivetting machines, with their respective lifting appliances, you will, I trust, now understand the general principles on which any hydraulic machine-tool installation is based.

The application of hydraulic pressure to

machine-tools was, until a comparatively recent period, confined to the working of a single machine at a time, each machine being fitted with suitable dies or tools for the work required to be done.

So long as "isolated" hydraulic machine tools were used, *i.e.*, each machine worked by its own pump, they were only suitable for special applications, and were all, more or less, mere modifications of the Bramah press, fitted with special tools. About the year 1864, it occurred to the author that the application of a complete system of storage, distribution, and application of hydraulic pressure to machine tools would prove economical. Commencing with the stationary rivetting machine, in 1865, and the portable rivetting machine, in 1871, this system has now, thanks to the hearty co-operation and valuable assistance in designing, applying, and manufacturing, of those gentlemen who have been associated with him, assumed such considerable proportions as to lead the author to hope that a paper on the subject before this Society would not be altogether without interest. With the introduction, at the same time, of a working pressure of 1,500 lbs. per square inch, these tools could be made comparatively small, relative to the power exerted by them. This greatly assisted ts further application to moveable or portable tools. This was an important step in advance, and with the invention of the transportable rivetter, to which the hydraulic pressure was carried from the accumulator by means of uninterrupted hydraulic connections, a new impetus was given to this class of machinery. The introduction of the portable rivetter gave to hydraulic machine tools a character entirely their own. Hitherto, when any bridge or girder work had to be rivetted up in large pieces, it could only be done by hand, as neither the work to be done or the stationary rivetter could be moved. By making the rivetting machine moveable, "Mahomet came to the mountain." Curiously enough, it was with a firm of engineers in the city of Gloucester that the author arranged for the manufacture of his portable rivetter (after many had declined it as visionary and impracticable.) Messrs. Fielding and Platt, however, desirous, doubtless, of maintaining the hydraulic traditions of their ancient city (already referred to) have ever since been identified with its extensions and development. The next application was to machines for flanging, forging, and stamping; these operations are peculiarly susceptible to hydraulic treatment, the substitution of a squeeze for a blow being manifestly less injurious to the material operated upon.

In all the above operations, although in the performance of it much less noise is made, the quality of the work done by hydraulic pressure is better; and, indeed, when boiler or girder works are placed in towns amidst dwelling houses, the hydraulic system is often specified on account of the absence of noise; for, if Shakespeare could write that—

> "The armourers accomplishing the knights,
> With busy hammers closing rivets up,
> Give dreadful note of preparation,"

What would he say of the notes produced in a modern boiler shop?

Now, considered *individually*, many hydraulic machines are not economical, when compared with geared machines, for doing the same work. [I am, for the present, however, neglecting the numerous cases where hydraulic machines perform operations which cannot be done by any other means]. Considered *collectively*, however, matters are just reversed, the economical results being more marked than those obtained on any other system. Why is this? It is because the losses incidental to the transmission of power by gearing more than counterbalance any economy in the machines themselves; while, on the other hand, in a hydraulic system, any loss of efficiency due to the application of this power to an individual machine, is more than made up by its economy as a transmitting medium.

It follows, therefore, that the more extended the application, the more economical are the results. The "accumulator," however, contributes as much to the economical efficiency of this system as any other factor in it, and I cannot, I think, describe this important feature, as well as the efficiency of hydraulic transmission generally, in clearer terms than those used by a French engineer, M. Marc Berrier Fontaine, in the course of a discussion on a paper on this subject, read by the author at the Institution of Civil Engineers. He said—

"The economy of hydraulic tools also resulted from their rendering mechanical transmission unnecessary, the maintenance of which was always extremely expensive. In its place was simple hydraulic tubing, requiring no maintenance and no repair. But still more did this economy arise from the employment of accumulators, which allowed of a considerable reduction of the engine-power that would be necessary for working by mechanical transmission in a place of

equal capabilities. . . . Besides, the employment of accumulators presented the great advantage of permitting a considerable quantity of work to be done during the time the engine was at rest."

It may be mentioned that, although the engines referred to by this speaker were capable of indicating 50 horse-power (having, as a precautionary measure, been made to develop the same power as would have been required to drive a similar works where geared machinery was used), they have, as a matter of fact, done this work, and more, with an average indicated horse-power of from 8 to 10 horse-power only.

The above was the first complete installation on the author's system, and he takes this opportunity of acknowledging the invaluable assistance rendered to him by M. Berrier-Fontaine, both in the theoretical and practical questions involved in the adoption of a system which was at that time quite a new departure. It may be mentioned that the execution of it was entrusted to Mr. Henry Chapman (a member of this Society), who was one of the first engineers to adopt and introduce this class of machinery.

It has hitherto been assumed that, so far as the quality of the work done is concerned, it would not matter whether the tool for punching a hole or shearing a plate was a geared or an hydraulic one. But in the working of steel, there is good reason to believe that much less injury is done to the plate by the steady pressure of the hydraulic machine than is the case when the punch is forced or driven through by a geared machine. In addition to these important points, it may be well, in conclusion, to refer to some other of the advantages gained by substituting hydraulic pressure in place of gearing or shafting in our engineering workshops. There is, in the first place, none of that great danger incidental to the use of shafting, namely, the number of lives lost and fearful accidents due to putting belts off and on to pulleys. Again, there is considerable difficulty, and certainly a great loss of useful effect, in transmitting power round corners by shafting. Owing to the limited distances through which any power (smaller ones especially) can thus be economically carried, it requires in many cases more power to turn round the driving shaft than is finally given out to the tool driven. In addition to the main shafting there are endless countershafts, pulleys, &c. and their position necessitates all the machines being brought as near the shafting as possible, quite irrespective of that being the best position for bringing the work to them.

In some cases the substitution of hydraulic pipes in place of shafting allows of the same number of machines being worked in two-thirds of the floor space. Since the hydraulic mains are all underground, the great cost of superstructure and columns of sufficient strength to carry the shafting is saved, and in addition to this economy above the earth, there is no expense incurred in foundations under the earth, since all these hydraulic machines are self-contained, and can thus be shifted about the shop floor when desired There is, of course, no danger of explosion with water, owing to the absence of elasticity; and should any leak occur, it is at once felt or seen, and easily remedied.

There is practically no limit to the distance through which hydraulic power can be transmitted; this has been done for upwards of two miles without any apparent loss of effect.

Time will not allow of my going further into the merits of hydraulic machinery in engineering workshops, but there is yet another most important feature, namely, its suitability and safety when applied to the moving, lifting, and lowering work about all the machine tools therein. There is also the important question of the cheap transportation of all material about works; for the latter, hydraulic capstans are used, and these useful appliances in some cases not only draw the hot plates and angle bars used for the frames of ships from heating furnaces, but also bend them to the required shapes. When these are of steel, the advantage of substituting this steady and smooth pressure, instead of doing it by many hundred blows by hammers, is obvious.

In its application to small cranes and lifts, placed above lathes and other machines, a much larger field for its employment is at once opened. In such cases the man who works the machine can, by means of a valve attached to it, also work the crane, thus dispensing with a labourer, and when properly disposed about the shop, one crane can serve several machines.

It has been impossible in this brief review of the subject to allude to particular installations or machines. In the form of an addendum, a brief description is given of the few illustrations illustrating this paper, and the description of the photographs which will now be shown on the screen—will serve to show to some extent the diversity of machine tools to which hydraulic pressure is now applied.

Finally, when we consider the immense im-

portance of good and conscientious workmanship on such structures as ships, bridges, or boilers, I think it absolutely necessary to eliminate as far as possible the elements of human fallibility, and, so far as I am aware, there is nothing more conducive to this than he employment of hydraulic machinery in engineering workshops.

Description of the Illustrations accompanying this Paper.

Fig. 1 (p. 190) shows a stationary hydraulic rivetting machine, with its hydraulic crane, the motions of the crane being controlled by the same man who works the rivetter. A labourer is dispensed with, and much greater accuracy in the work done.

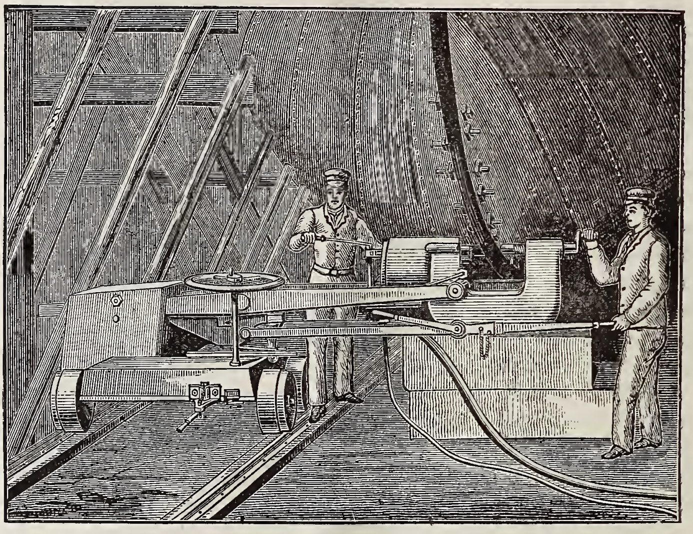
Fig. 2 (p. 192) shows a hydraulic shearing machine. The advantages of this class of machine are referred to later on, in describing the photographs.

Fig. 3 (p. 193) shows various types of portable rivetters, grouped round the bottom framework and keel of an iron or steel vessel. The various portable machines are described later on, and the keel rivetter also.

Fig. 4 shows the keel rivetter putting in the rivets which connect the bottom row of plates, or shear strake to the keel of a vessel. While

Fig. 5 (p. 197) illustrates the application of the portable rivetter to closing the rivets in ships' frames before they are up-ended on the keel.

Fig. 4.



Ship's Keel being Rivetted by Hydraulic Power (Tweddell's System).

The paper was fully illustrated by photographs of the principal types of hydraulic machinery, exhibited by means of the lime-light.

Description of the Photographs.

No. 1 shows a stationary rivetting machine, with its crane. The action of this has already been described in referring to Fig. 1 illustration. The next photograph brings us to the subject of portable rivetting machines. These can be worked from the same pumps and accumulators as the stationary ones. They are of several types, and, as will be seen, assume various forms to suit all classes of work. In working out these and the cranes, and other accessories, the author has received valuable assistance from Mr. James Platt and Mr. John Fielding, of Gloucester, who are, in many of them, his co-patentees.

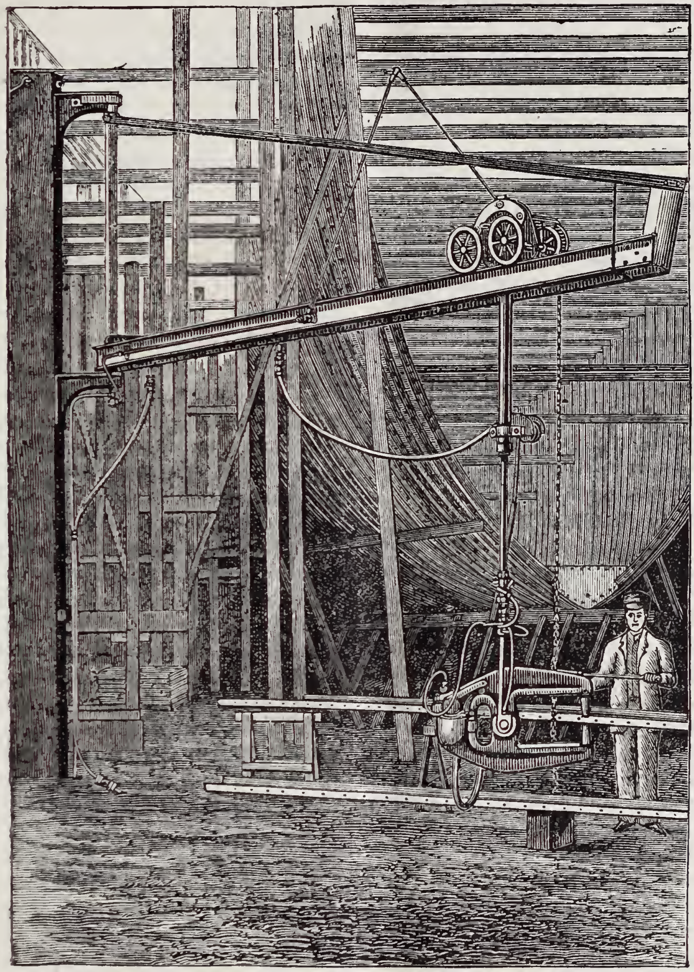
No. 2 shows (1) a portable of the first type, invented in 1871; this is a machine consisting of two levers, which advance and recede to and from each other, by means of two tie-rods, connected to an hydraulic ram working in a cylinder. The cupping dies are shown at the lower end; in many cases, the lengths of the levers are different on either side of the tension rods; this of course causes the pressure at the ends of the lever to vary also, and, consequently, by changing the dies to either end, different powers can be brought to bear on the rivet.

No. 3.—This is a direct acting portable machine, and is the simplest form; it can also be made with two or three different powers, by making suitable arrangements of the rivetting rams. Above this machine is shown a hydraulic lift; this lift serves not only to adjust the machine to its work, but also to carry the pressure

water to the machine, there are, consequently, no pipes hanging about and getting into the way of the men, and the work it is being employed upon; these machines are made up to 5 feet, and even 8 feet gap, and more, but in the cases of the latter sizes, it requires some power to manœuvre and apply them to their work.

No. 4 shows another type of portable, known as the "Fielding" class; this is also a lever machine, but the levers are of a different order. The arms, or levers, work upon a central gudgeon, and in order to allow of both the rams and cylinder remaining, practically, solid portions of the frame (and thus ensuring all the stiffness of machines in one casting), the cylinder is curved to a radius corresponding to its distance from the fulcrum.

FIG. 5.



SHIP'S FRAMES BEING RIVETTED BY HYDRAULIC POWER (TWEDDELL'S SYSTEM).

No. 5 is a machine of a similar class with a universal hanger; the model exhibited shows, that practically the cupping or rivetting dies of such a machine can be brought to any desired point.

When we come to deal with large installations comprising not only the rivetting up of work, or the driving of two or three tools, pumping engines of a much more powerful character are required.

No. 6 shows one type of engine for this purpose; these engines indicate about 50 horse-power; the pumps are placed in a direct line with the engine cylinder with a fly-wheel; but very successful pumping engines are at work without any fly-wheel at all,

while others are made vertical, and in many cases on the compound principle.

Having now assumed our pumps and accumulators placed in position, we will first illustrate some of the machines as used in a ship-building yard, and then some of those required in a boiler yard, and finally those more especially suitable for girder work and bridge building. It may not be amiss at this point to mention that for all these different classes of work the hydraulic power is equally suitable and available (thanks to the accumulator) for working cranes, capstans, &c., for taking the work to and from the machines.

Assuming, therefore, that all the material in the shape of plates, angles, and bars, has been brought nto the shop by means of hydraulic capstans or cranes, one of the first operations is to punch the holes and shear the plates, and I need hardly mention that the machinery for doing these operations is equally applicable to all the different classes of shops above referred to.

No. 7 shows a hydraulic machine for shearing; this can be worked either by the foot or hand. A great feature in hydraulic machines for this class of work is the facility with which they can be adapted to do other work of a very different character. These machines are superior to those driven by belting in, amongst others, the following features:—Firstly, each end is quite independent of the other; thus, any accident to the one does not, as in a geared machine, disable the whole machine. Again, if only one end is required to be used, the power necessary to drive it is in exact proportion, whereas, in geared machines, the same fly-wheel, and, practically, all the gearing have to be kept going, whether both ends or one are at work.

The most important feature, however, is that, since the man working it has perfect control over the movement of the rams, much more accurate punching work can be done; the tool can, practically, be stopped when it has touched the plate. In ordinary geared machines, the maximum number of strokes of the tool once settled, the tool must make these, whether a hole is to be punched or not; this involves a great waste of power. Finally, the bad effects of punching in steel plates is, to a great extent, done away with, owing to the steady pressure employed by which the materialisd is placed gradually, instead of its being as it were forced out.

No. 8 shows a modification of the last machine, but arranged with knives or shears to cut angle irons; after they are cut on the shearing side to the right lengths, they are punched at the other end.

No. 9 shows a manhole punching machine, and is used to punch out at one operation such pieces of plate as that exhibited.

No. 10 illustrates a machine for bending angle or other irons to the desired shapes—to fit them in the ships. This is another operation for which hydraulic pressure is very suitable. The views 7, 8, 9, and 10 just shown, show a class of machinery of which considerable numbers have been made to the author's designs, by the Hydraulic Engineering Company, of Chester.

No. 11.—We now come to putting together the work thus punched, sheared, and bent to the desired forms. No. 11 shows the frame of an iron vessel being rivetted up by a portable rivetter, at the Atlas Works, Gloucester, in 1872-3; upwards of 1,000 rivets per day were put in even by this very temporary arrangement.

No. 12, and Fig. 5 in paper, shows a plan of doing this class of work, proposed by the author in 1875-6. In this arrangement a jib crane is placed at either side of the berth on which the vessel is being built. The portable rivetter and lift is suspended to each crane, and as the frames pass down between the cianes, they are rivetted up by the machines and there up-ended. Each machine can put in from 1,000 to 1,200 nuts in ten hours.

No. 13 shows the portable rivetter, rivetting up tank, or as it would equally well do, portions o bulk heads, &c. The crane which carries this is, however, specially designed to allow of the rivetting of the ship's hold beams. When those beams and frames are complete and connected, they are ready for receiving the keelsons which tie them together.

No. 14 illustrates a portable rivetter doing this work; the importance of doing work well is obvious. We then come to rivetting up the longitudinal stringers, for which the special carriage shown in

No. 15, has been designed. This allows of the rivetter being housed within it, and thus enables all hold beams, &c., to be cleared. This machine has a gap of nearly 5 feet, and can put in many hundreds of rivets per day.

The next operation in shipbuilding is, of course, to put on the shell plating. No one has, as yet, succeeded in doing all of this, or, indeed, any appreciable per-centage of it, but many minds are engaged upon it, and, with the assistance of naval architects, I have no doubt that it will soon become practicable.

No 16 photograph and Fig. 3 in paper shows a group of machines doing various kinds of work on a ship's hull; the one on the right hand side you will see is engaged on the second strake of plates.

No. 17 (and Fig. 4 in paper) shows the keel rivetter closing the rivets connecting the bottom or garboard strake to the keel. This is a most important part of a vessel's structure; and since, by simply reversing the machine, it can also rivet the shear or top strake, we have both the top and bottom members of the girder which constitutes a ship rivetted by hydraulic power.

Coming now to a few of the hydraulic tools more especially suited to a boiler yard. The first in order is a flanging machine. The one illustrated—

No. 18, is the invention of M. Gustave Piedboeuf, and has proved very successful. Its chief advantages are that by the use of four gripping rams, the plate is kept quite flat while its edges are being turned over. A defect in this class of press is

that for every different shape, or size of plate, a complete set of new moulds or dies are necessary. This is expensive, even for small work, although, for instance, as in locomotive work, it pays well when there is enough repetition; but for marine boilers, which are often of great diameter, say 14 to 16 feet, it is impracticable. To overcome this, Messrs. Fielding and Platt and the author, in conjunction with Mr. William Boyd (who in, 1865, as a partner in the late firm of Thompson and Boyd, of Newcastle-on-Tyne, made the author's first hydraulic rivetter), designed the flanging machine shown on

No. 19.—This press, it will be seen, has two rams, and in this view they act as one, being tied together by the top die. The object of having two vertical rams is, however, shown on

No. 20.—You will now observe that the outer one grips or holds the plate tight, while the inner one, by means of a suitable die, turns the plate over, There is yet another ram, at the end of which is a "set," or block; on this advancing horizontally, it squares up and finishes off the work. It will be observed that the plate is free to move on a centre, and therefore only a very small block is required; in fact, the blocks used are similar to those required for hand work.

No. 21 shows a portable rivetter putting in the rivets connecting a cast-iron or other mounting to a boiler; while

No. 22 shows another special form of portable, rivetting on a ring to the end of a torpedo casing. This form of portable was first designed for the more peaceful purpose of rivetting the firehole doors of Mr. Webb's locomotive engines at Crewe, at which works the earliest adoption of this system for locomotive work took place; and Mr. Webb is now able to state that every rivet is put in by a power which is always uniform, and literally never "strikes."

The expression "portable" rivetter is, of course, a relative one; and while

No. 23 shows a portable rivetter weighing 3 cwt.,

No. 24 shows a machine designed by Mr. W. H. Panton, of Stockton, on the author's system, which weighs over three tons. This machine has a gap or reach of 8 ft., and can put in every rivet in a girder 16 ft. deep if required, without moving the work.

The question of cranes and suitable lifting tackle soon became of the first importance for such tools. In Mr. Panton's works he used an overhead traveller, or Goliath.

No. 25 shows a very usual plan—namely, a small travelling jib crane. This is suitable for light or small machines.

No. 26 shows a travelling crane. This is fitted with a multiplying hydraulic chain lift, and walking pipes, to convey the pressure to the rivetting machine without interruption, in whatever position it may be. This traveller is 40 ft. span, can travel longitudinally, with ease at 50 ft., and has a vertical range of 25 ft. Thus the machine can be moved to any desired point in a cubic space of 50,000 ft. without making a new connection; of course, by making one connection with the longitudinal walking pipes, we increase this to 100,000 cubic feet, with only one joint to make.

No. 27 we see another type of crane, which, with the "Fielding" type of rivetter attached to it, has recently put in 4,000 rivets per day, in India.

In this case the whole crane moves, and thus it goes from one end of the bridge to the other, while it is being erected. The cross traverse is obtained by a suitable flying gantry carried on the end of a jib. The more minute vertical adjustments are obtained by means of a small hydraulic lift attached to the rivetter.

A small reverberatory rivet-heating furnace is also attached to the trolly, and serves as a counterbalance to the rivetting machine.

The pumping and accumulating power is on another truck, which follows this one.

No. 28 shows a travelling crane, in which everything is self-contained—steam-engine, boiler, pump, accumulator, and all, are on the one trolly. This is a very economical arrangement, since, after heating the rivets (which must, in any case, be done for large work), there is enough heat left to raise the steam required for driving all the machinery which puts them in.

No. 29 shows a similar plant as actually used (for the first time for such a purpose) to rivet up the bridge carrying Primrose-street across the Great Eastern Railway Company's rails at Liverpool-street. The jib is made of the great height shown, so that the machine could be applied later on to the top members corresponding to the bottom ones, which had just been laid down when the photograph was taken.

No. 30, finally, is a photograph of a hydraulic forging machine; this, as already mentioned, is a very suitable class of work to apply hydraulic machinery to. The subject, however, is one for a paper itself, and this photograph is merely exhibited so that so important a field for hydraulic machinery should not appear to have been neglected.

DISCUSSION.

Professor UNWIN said it was pretty clear that Mr. Tweddell had obtained a complete monopoly in this new field for the application of hydraulic power. One of his students, Mr. Sulivan, at Cooper's-hill, who went to India, and had somewhat distinguished himself, completed a contract for erecting bridges on one line of railway there, at the rate of one span in seven days. Whilst staying with him a year or two ago, he had the offer of another contract, conditionally on erecting all the bridges on the line at the rate of one span in four days, the span being about 150 ft. He knew he could not do it with the native labour he had employed before, but by using some of

Mr. Tweddell's machinery, he was able to fulfil the contract successfully. He had the opportunity of seeing some very remarkable indicator diagrams which Mr. Tweddell published, taken from the pressure cylinders of his machines in the Toulon dockyard, and everyone who saw them must have been struck with the remarkable way in which they differed from those taken from an ordinary steam-engine. In steam and gas-engines, and others of that kind, however, one was dealing with a fluid of comparatively little weight, so small in fact, that practically it was neglected in dealing with the dynamics of the machine; but in the case of water, you had a fluid 500 times as heavy, and could no longer neglect the weight driving the piston. With a very fast running engine, by altering the weight of the piston, the turning effort which it exerted on the crank shaft could be considerably altered; and it occurred to him that with hydraulic machinery you had practically a very heavy piston, but until he saw these diagrams he had no idea how very large the weight of that piston might in some instances become. In one case he calculated the weight, where all the conditions of the problem were in one machine, a rivetter worked from a differential accumulator. The accumulator was connected with the rivetting machine by a small pipe only containing 10 lbs. of water, but as that 10 lbs. moved eighty-one times as fast as the ram of the rivetter, the inertia of 10 lbs. was equivalent to an inertia of 30 tons attached to the rivetter piston. In that case, the weight of the accumulator also was practically part of the piston of the machine, and he found that in fact there was in that machine an inertia equivalent to a weight of 300 tons. Drawing a sketch of the diagram in question on the black-board, Professor Unwin pointed out that in the earlier part of the stroke there was a large area representing work done in the accumulator, which did not appear as work in the rivetter diagram, not being balanced by the small excess of work at the end of the stroke. By calculating the speed of the machine, taking into account the huge virtual weight of the piston, and thence deducing the frictional loss in the pipe, a diagram was obtained in which the work stored in the first part of the stroke almost exactly balanced the work restored afterwards.

Mr. Ellington said he could not help thinking, in listening to the paper, what a large field for ingenuity there was in the direction of shop machinery. The progress already made was very great, and nothing could show more clearly the advantages of hydraulic transmission. Reference had been made to the installation in London of hydraulic apparatus for distribution and general use, and if any one doubted for a moment the economy which would be gained by this method, he would ask them to look at the central pumping station of the company, and imagine that there were some ten miles already laid of hydraulic mains, all worked from that one station. Mr. Tweddell had spoken of Toulon dockyard, where an engine of 50 or 60 horse-power, which would have been too small to drive ordinary geared machinery doing the same work, was found to accomplish all that was required while indicating on an average not more than some 8 or 10 horse-power; in the same way there were now working some 150 machines within this radius of ten miles, all driven by an engine which was capable of delivering about 150 horse-power into the mains, but it was not found that more than half that power was expended. When all possible leakages were taken into account, he could not help thinking that this was a most remarkable result. The successful application of hydraulic machinery was mainly a question of accuracy of work in details, and of good design in laying it out. There was a great deal to learn, and those who thought that the matter was very easy and simple, would find out their mistake. It required a great deal of enthusiasm and steady patient industry, of which so good an example had been shown that evening.

Professor Perry said that anyone who had used a screw-jack, and compared its efficiency with that of a hydraulic jack, must feel that the introduction of hydraulic machinery would effect a very great saving in power. A screw-jack had an efficiency of about 18 per cent., whereas that of a hydraulic jack was not less than 80 per cent. This was a very important point, however difficult it might seem to be to introduce peculiar-shaped tools for particular operations. Two or three years ago, in that room, he had referred to these indicator diagrams of Mr. Tweddell's as being very remarkable, and he then said he could not account, either by friction or in any other way known to him, for the apparent excessive loss in the early part of the stroke. No one could be more gratified than he was to find that Professor Unwin, on going carefully into the question, had actually accounted for all the loss. At that time the only conclusion he could come to was that, although at ordinary pressures there did not seem to be more resistance to the passage of water along pipes at great pressures than at small, still, at very high pressures—say, from 700 lbs. to 1,000 lbs. per square inch—it seemed as if there were a great increase in the friction, and that the kinetic energy of the water was really destroyed. This showed that shocks in hydraulic machinery, stoppages of pumps, &c., led to a considerable loss of power; and, considering this, it seemed very odd that pumps working from high lifts should be so much more efficient than those at low levels. It also pointed to this conclusion that, when you had rapid changes of motion, and therefore shocks, you could not expect great efficiency from hydraulic machinery. He should therefore doubt whether the application of hydraulic machinery to rapidly running machines, such as lathes, &c., would be so economical as its application to such machines as Mr. Tweddell had referred to. In a lift you had a long, steady, slow stroke, and no sudden change of motion, and there, probably,

there would be an efficiency of something like 85 per cent. In the rivetting machines there was a gradual application of very great pressure; and there, also, very great efficiency might be expected; but, probably, the true value of these machines would not be appreciated without an examination of the rivets actually made by it. Some years ago he had examined some which had passed through five or six plates, and was much struck with the perfect symmetry between the head and the shank, which he did not think could be produced in any other way. The great advantage, however, was that no foundation pillars or shafting were required; you simply had a thumb and finger pinching motion, requiring great strength in the moving parts, but nowhere else, and the motive power came as in the electric driving of machinery through a flexible connection. Another point was that the workman had complete command of the machine; if he were punching a hole, he could stop when the plate was only slightly indented, which would be utterly impossible with a machine having a fly-wheel. Again, if by accident an inch plate was put into the machine only calculated for a $\frac{5}{8}$ rivet, no harm was done, the machine would simply stop, whereas in a geared machine, something must break.

Mr. PLATT said actual practice quite bore out Professor Unwin's theory with regard to the indicator diagram. They commenced with the idea that the rivetters should be made as light as possible, but this was found to be of not much consequence. If, in closing rivets, the accumulator should happen to come down by being drawn upon by another machine, the rivetter could not be properly worked by the pump direct. It would have the same static pressure upon it; but still the rivet was not properly formed, and would have to be cut out, showing the enormous difference in the quality of the work between the use of pumps only, and the use of an accumulator. They had always admitted that there was a considerable loss of power, but it was more apparent than real, for the power sufficient to work a hydraulic rivetter would not work a geared machine. Other engineers were dispensing with the accumulator, but to his mind it was the very life and soul of the whole thing. They put enormous power into the pumps, and yet delivered less power into the rivetters. The same strength of machines which were used without an accumulator, and by which the same pressure was professed to be obtained, would not stand Mr. Tweddell's system a moment.

Mr. PRINCE asked Mr. Tweddell if a duplicate plant and pressure mains were erected at the central station, so as to avoid stopping the whole of the machinery dependent upon it if any accident occurred?

Mr. J. N. SHOOLBRED said a very interesting and extensive example of the use of hydraulic rivetting and other machinery was presented at the Forth-bridge, which he had visited several times lately. The several machines, though not of Mr. Tweddell's design (being designed by Mr. Arrol, one of the contractors), were of a kindred character. One among the many advantages of hydraulic work was its superiority over hand-work.

Mr. BENNETT said he had used hydraulic machinery to a considerable extent at the Horsley Works, with great success, and with advantage to the material. He had also forged by hydraulic pressure instead of having recourse to the steam-hammer. One test of the utility of the system was the relative cost compared with hand labour. In one particular case they wanted about 15,000 brackets of a particular kind, made of angle iron, the ends of which had to be welded. The labour cost of bending them would have been about 9d. each, but he did them infinitely better by hydraulic pressure at about $1\frac{1}{2}$d. each. They had to be heated, but a much less heat was sufficient. With regard to economy, and the loss of power which sometimes occurred, he might say that he had made a horizontal hydraulic machine, the travel of which was 2 ft. 6 in., for bending the knees of large girders and work of that kind, and as there was considerable loss of water in the process, he applied a small ram on each side to take the horizontal ram forward to the pinch of the work and bring it back again. The small rams did a large part of the work. When they had exhausted their power, the pressure from the accumulator was brought on by turning a wheel, and he had also another accumulator, the power of which could be added just at the finish, and the work was simply perfect. He thought perhaps Mr. Tweddell was a little too enthusiastic about it, for he did not agree with him as to the advantage over geared machines in punching plates, and he had both in use. He rather thought the days of punching were over and the days of drilling were coming in; and that it was to the perfection of drilling, and the perfect manipulation of steel and iron of a higher quality, to which attention must be paid; but in that hydraulic machinery would greatly help.

The CHAIRMAN, in proposing a vote of thanks to Mr. Tweddell, said, he had omitted to mention the earliest record of a mechanical mode of raising water, viz., in Deut. xi., 10, where Moses told the Israelites, "For the land, whither thou goest in to possess it, is not as the land of Egypt, from whence ye came out, where thou sowedst thy seed, and wateredst it with thy foot, as a garden of herbs;" it always seemed to him that that passage pointed to the kind of hydraulic machine, used in some parts of India, even to the present day. In this machine there was a plank placed horizontally, and supported near the centre, on a fulcrum; at one end of this plank there was a bucket, which, when that end was down, dipped into the water to be raised, and a man walking along the plank altered the balance as he passed from one end to the other, thus dipping up and

raising the water. The hydraulic mode of working machinery practised by Mr. Tweddell, was interesting, not only in itself, but in connection with the larger question of the distribution of power. On the previous evening, in another place, he had occasion to say that he believed the time was coming when it would be found desirable, where comparatively small power was wanted, or even large power intermittently, to procure that power from a central ource, instead of providing it at each place where it was required. This matter had been before him since his apprenticeship, some fifty-one years ago. The engineer to whom he was apprenticed, Mr. Hague, proposed and carried out a plan of laying on power by exhaustion. He laid on mains, with air-pumps at one end, not to compress the air, but to exhaust it to about half an atmosphere; then at the place where the power was needed, the pipes were connected with the exhaust pipe of an engine like an ordinary steam-engine, and the atmosphere pressing on the piston with a pressure of about 7 lbs. to the square inch, worked the engine. Unfortunately, Mr. Hague was somewhat dilatory, and thus lost a fine opportunity of laying on power in this way very extensively. When the St. Katharine Docks were near completion, he obtained permission to put up a system of pneumatic cranes on this system, but after keeping everybody waiting for more than twelve months the company got tired, and put up ordinary cranes instead. But these pneumatic cranes were used successfully in many instances, particularly in collieries, where they were useful in aiding ventilation, and they were also used in sugar houses and other places. Mr. Tweddell had read, with some amusement, Mr. Bramah's early specification, and no doubt the last part of it was of a comprehensive character, but Mr. Bramah did condescend on some details. Mr. Tweddell seemed surprised at the claim that you could plane hydraulically. But, as a matter of fact, Bramah did plane hydraulically, for he had himself seen the machine at work years ago in the gun carriage department at Woolwich Arsenal. There was a vertical revolving spindle carrying a horizontal wheel revolving with considerable rapidity, on the rim of this wheel were cutting tools projecting downwards. On each side of the spindle was a bed, carrying a sliding table, on this the log was placed, and the cutters revolving in contact with the log planed it. The log itself was drawn forward by a hydraulic cylinder, and not only so, but the thickness of the cut was regulated hydraulically; for the vertical spindle of the wheel carrying the cutters worked through a stuffing box, but stood upon water, and according as the water was pumped in below it or let out, so was the position of the cutters with respect to the log; and thus the thickness of the cut was regulated. Mr. Tweddell had told them that one of his rivetters was also used for weighing the work, and he might mention in connection with that, a beautiful testing machine by Mr. Emery, an American engineer, and in use at Watertown Arsenal, near Boston. This machine he believed would be shown in the forthcoming Exhibition at South Kensington. It was one of the most beautiful apparatus he had ever seen for the application of fluid pressure as a means of testing strains. It recorded these upon a scale (where they could be read off) with the greatest possible accuracy. He was sure there was not a mechanic in England who would not admire that machine when he saw it. With regard to the question raised by Professor Unwin, as to the excess of pressure over and above that in the accumulator, he presumed it arose from two things; one the friction in the pipes, and the other the momentum acquired, not only by the metal in motion, but by the water in motion through the pipes, which, small as its weight was, yet having regard to the rapidity with which it moved through pipes which were of such small diameter in comparison with that of the cylinder, would really act as a hydraulic ram. One was not surprised at the action of a hydraulic ram, under ordinary circumstances, and he did not know why the fact should be overlooked that water under these heavy pressures would act in the same way as it did in a Montgolfier hydraulic ram. Some twenty years ago he experimented with Chatelier's brake, the idea of which was simply to reverse the locomotive; but it was found that heat was generated in the cylinder, this got scored, and the piston packing was burned. It was suggested then to turn some water from the boiler into the cylinder to lubricate it, this water was converted by the heat into steam, which was pumped back into the boiler. The slide gear was simply reversed while the engine was running; the piston, at first, only moved forward against the atmospheric pressure, then of a sudden the slide valve was opened as the piston was in full motion, and it had to drive the steam which came in from the boiler back again. It was found that the pressure created in the cylinder was largely in excess of that in the boiler. The first suggested explanation of this, was that it must be owing to the friction in the pipe due to getting the steam back into the boiler, but that would not account for the steam rising above the boiler pressure at the moment when it came into the cylinder. On further investigation he found that the engine on which the experiment was tried was one in which the "steam regulator" was close to the fire-box; there was a pipe from the "regulator" the whole way to the smoke-box, and then it branched to the two cylinders, and when he calculated the relative areas of this pipe and of the cylinders, and the weight of steam in the pipe, it was easy to see that the weight of the steam in motion was sufficient to produce the extra pressure, and even much more. That was an instance of the Montgolfier ram action in steam, and corroborated the theory that the same action took place in hydraulic apparatus. With respect to the application of hydraulic machinery to circular motion, driving lathes, &c., it had been suggested that that was not the true function of water power, because of the frequent change of motion in the cylinder which was

required. He would point out, however, that in the case of the rivetting machine, there was a great length of pipe in which the water was at rest; when the rivetter was started, and a sudden and rapid movement of the water ensued, and then suddenly stopped. When, however, water was applied to drive a reciprocating engine in order to produce rotary motion, it was true you had to change the direction at each end of every stroke, but the water was not arrested in the whole length of the pipe; it was only in the valves that the change of direction took place, and therefore he should imagine the efficiency would still be so great as to make it very desirable to employ machines of this kind where power was supplied from a central source. The last time he occupied thls chair was when Mr. Preece read a paper on "Electric Lighting," and he then brought forward a complaint that that mode of lighting had been stopped in England by the Electric Lighting Act, which confiscated the shareholders' property. It was a fortunate thing for the development of the transmission of hydraulic power, that that Act was not passed before the one authorising the distribution of hydraulic power in London; there was, however, a town where an Act for a similar purpose was obtained last year, and where the consent of the corporation had to be granted, and that was only given on condition that the pipes and all the plant were to be compulsorily surrendered to the corporation after a certain number of years, at prices which, although certainly better than those suggested in the case of electric lighting, yet still meant confiscation of an industrial enterprise by a local authority. He much feared that unless a strong expression of public opinion were made, the end of the application of private capital to public purposes would rapidly arrive.

The vote of thanks having been passed unanimously,

Mr. Tweddell said it was impossible to discuss the theory of Professor Unwin in the short time at his disposal. But while it would be most satisfactory to have the point cleared up theoretically, after all, what practical men were concerned with was the result; and this, as he had shown, was an immense saving in the power required to perform a certain quantity of work. The reason why it was so, they were quite content to leave to such gentlemen as Professor Unwin to work out, and to his mind the train of reasoning so ably given by him was the correct one, and he hoped would be followed up by one so well able to deal with it. He had not, during an experience of twenty years, found any necessity for duplicate pipes. If there were a collision on any main line railway, and the line thus blocked, all traffic was stopped for a time; and so if a pipe burst, operations would be stopped, but it could be repaired in the course of a few minutes. The danger was minimised in all the works properly laid out, by an arrangement of stop valves, so that in case of an accident at one portion of the pipes, the remainder of the machines could still be used. He had never heard of an accident occurring, and the system had been largely in operation in Hull for some years. In America, where they used steam in the same way, travellers were sometimes alarmed by the whole road suddenly rising up, but with hydraulic pressure that was impossible. Mr. Shoolbred's remarks were very satisfactory; nothing was more pleasant than for one who had introduced a new system to hear of its successful carrying out or extension by others. But so far as he was aware, nothing was being used at the Forth-bridge which he had not had an opportunity of carrying out many years ago. A great deal of experience and skill was required in the development and extension of any system, and the greater the number of minds engaged upon its development, the better for all concerned, and its ultimate success. Mr. Bennett's observations were of great value, and similar plans to those he had mentioned, for economising the use of water under pressure so as to only employ it when really required, had been used by the author; but, after all, it must be borne in mind that, as a rule, the application of too many economising appliances to hydraulic machinery was not judicious; that, at any rate, had been the experience of those who had had to do with it for any length of time. As to the drilling and punching question, he had always understood that the latter process was preferred by the bridge builder. He never could see why the work of boiler or bridge building should not be considered as much a branch of engineering as that of putting engines together. There was more risk and responsibility involved in the construction of a boiler than in that of any marine or other engine. Yet, up to the last few years, almost anything was thought good enough for a boiler shop. Happily, that was not the case now. Sir Frederick Bramwell had sprung a mine upon him in his reference to Deuteronomy; but he still maintained that his claim on behalf of Ctesibius as the first hydraulic engineer was correct, so far as high-pressure hydraulic machinery was concerned, and in his paper he had distinctly limited his claim to this branch of the subject. With regard to the use of central stations for distributing power, he did not think any one could dispute the justice of the Chairman's remarks. The same thing was seen in every walk of life; there was a tendency (as shown even in the stores) to centralise everything, and to do away with the smaller men. He did not think this was an unmixed blessing, however, but the contrary, and he anticicipated that when power could be economically supplied, we should see small establishments springing up again along the line on which power was supplied, and thus be better able to compete with larger concerns. He pointed this out some time ago in a paper read before the Institution of Civil Engineers. With regard to rotary machines, the question could only be solved by practical experience; in suitable circumstances he

believed hydraulic power would be found very useful; but he quite agreed that it was desirable not to run away with the idea that there was nothing like water, and imagine that it must be superior to any other power for every possible purpose. He had endeavoured to avoid that danger, and not to be too enthusiastic, but simply to speak of what had been practically and successfully carried out.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The following circular letter has been issued by the Secretaries of the Physical Society:—

"Physical Laboratory,
"South Kensington,
"January 9, 1885.

"DEAR SIR,—The Members of this Society are doubtless aware that in the International Exhibition of Inventions to be held at South Kensington in the course of this year, a prominent position will be assigned to Collections of Scientific Apparatus. It has appeared to the Council of this Society very desirable that the Society should avail itself of the opportunity thus afforded of exhibiting in a collected form any apparatus, diagrams, and appliances which relate to communications made to the Society, so as to put in evidence the work done by the Society since its foundation. The Council have accordingly applied for space for such an exhibition, to be held under their direction, and members are requested to send to one of the secretaries of this Society the particulars of whatever they desire to exhibit. As the space at the disposal of the Society is necessarily limited, such particulars should be sent as early as possible, together with an approximate estimate of the space required. The exhibition, if made worthy of the Society, must involve some expense in arrangement and supervision, the disbursement of which out of the ordinary funds of the Society might entail a postponement of the publication of the books which the Society has undertaken to issue; and, to avoid any such postponement, the Council invite from members subscriptions, which would of course be purely voluntary, for the purpose of defraying the additional expenditure.

"Yours faithfully,
"A. W. REINOLD, } *Hon. Secs.*"
"WALTER BAILY, }

The celebrated Basilerski collection of objects of old Christian art has been purchased for five and a half million francs for the Emperor of Russia. Many of the objects in the collection are of German workmanship. The collection ranges from the 2nd to the 16th century, and is particularly rich in objects of the Renaissance period.

COMMUNICATION BETWEEN THE SHORE AND LIGHT-SHIPS.

It often happens that a vessel is lost after battling with the sea for several hours in sight of a light-ship, and might have been saved if a message could have been sent on shore. But the difficulties in the way of affording such communication have hitherto been regarded as practically insurmountable. They originate mainly in the constant and excessive motion of the light-ships, which are moored at the bow by a chain cable 4½ in. in circumference, "payed" out sufficiently in rough weather to allow them to ride and swing freely. In this way they often describe a complete circle; and, to prevent the telegraphic cable from being fouled by the moorings, if separate from the latter, especially as it would have to be similarly "payed" out to keep it from parting, has been the main problem. Another danger to be guarded against was that of damage to the telegraphic cable by ships' anchors light-vessels being generally moored in shallow waters. A year or two ago, however, the whole matter was placed in the hands of the Telegraphic Construction and Maintenance Company (Limited); and a contract was entered into whereby, as a practical experiment, they were to electrically connect the Sunk light-vessel with Walton-on-the-Naze, and maintain such communication for one year, no payment being made in the event of any failure to comply with the conditions, unless such failure should arise during the working of the cable from exceptional causes for which the contractors could not fairly be held responsible. The first part of this contract has now been fulfilled, considerable delay having previously occurred, owing to the necessity for several series of experiments at the company's works and elsewhere. It was foreseen at the outset that, to guard against the dangers already indicated, the telegraphic cable must be enclosed within the ship's moorings; and to determine the best form of the latter the experiments in question were undertaken. Ultimately it was resolved to adopt a hollow steel wire rope, 8½ inches in circumference, formed by fourteen twisted strands; and this rope—capable of bearing a tensile strain of 70 tons, and having the telegraphic cable running through its centre—constitutes the present ship's mooring, in lieu of the chain of 4½ inch circumference previously employed. On the 3rd December the contractors commenced the operation of laying the cable and moorings. Owing, however, to strong south-westerly winds, little could be done for several days beyond fixing the telegraph instruments, consisting of a Morse transmitter, a Wheatstone A.B.C., and a telephone on board the light-vessel, and also at Walton-on-the-Naze, and laying the shore end of the cable at the latter place; but on the 7th and 8th December the entire work was accomplished with a success which promises well for its future working. This light-ship, moored in ten fathoms at low water, is about nine miles from

Walton-on-the-Naze. The cable passes under the public road to the post-office at that place, which office is in direct communication *viâ* Colchester with Harwich, from whence the various lifeboat stations along the coast are easily accessible by telegraph.—*Electrician.*

General Notes.

KÖNIGSBERG EXHIBITION. — An International Industrial and Polytechnic Exhibition for machinery, motors, tools, appliances for mechanics, small manufacturers, &c., has been arranged to take place at Königsberg, from May to August of the present year. It is expected that, amongst others, great numbers of Poles and Russians will visit Königsberg during the time of the Exhibition. The following are some of the heads of groups under which exhibits will be classified, viz. :—(1) Motors; (2) transmission appliances; (3) tools and implements for all branches of trade manufacture; (4) chemical and physical apparatus; (5) apparatus for technical instruction; (6) safety and protective appliances for household purposes, and innkeepers; (8) agricultural implements and appliances, &c. The Exhibition takes place under the authority of the directors of the Industrial Central Union of the province of East Prussia. Dr. N. Heinemann, of the New Athenæum Club (Pall-mall east), London, has been appointed special commissioner of the Exhibition for Great Britain.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock :—

THE FOLLOWING DATES HAVE BEEN FIXED :—

JANUARY 21.—"Labour and Wages in the United States." By D. PIDGEON. The Hon. J. R. LOWELL, the American Minister, will preside.

JANUARY 28.—"The Influence of Civilisation upon Eyesight." By R. BRUDENELL CARTER, F.R.C.S. R. J. MANN, M.D., F.R.C.S., will preside.

FEBRUARY 4.—"Education in Industrial Art." By CHARLES E. LELAND.

FEBRUARY 11.—"Report of the Royal Commission on Metropolitan Sewage." By Captain DOUGLAS GALTON, C.B., F.R.S.

DATES TO BE HEREAFTER FIXED.

"The History and Manufacture of Playing Cards." By GEORGE CLULOW.

"The Musical Scales of Various Nations." By A. J. ELLIS, B.A., F.R.S.

"A Marine Laboratory as a means of Improving Sea Fisheries." By Prof. E. RAY LANKESTER, M.A., F.R.S.

"Recent Improvements in Coast Signals." By Sir J. N. DOUGLASS.

"The Evolution of Machines." By Prof. H. S. HELE SHAW.

"The American Oil and Gas Fields." By Professor JAMES DEWAR, F.R.S.

"Past and Present Methods of Supplying Steam Boilers with Water." By W. D. SCOTT MONCRIEFF, M.Inst.C.E.

"The Rivers Pollution Bill." By J. W. WILLIS-BUND.

"Malt-making." By H. STOPES.

INDIAN SECTION.

Friday evenings at Eight o'clock.

JANUARY 23.—"The Agricultural Resources of India." By E. C. BUCK, Secretary of the Government of India in Revenue and Agricultural Department.

FEBRUARY 20.—"The Teak Forests of India and the East, and our British Imports of Teak." By P. L. SIMMONDS. Colonel MICHAEL, C.S.I., will preside.

MARCH 6.—"The Trade between India and the East Coast of Africa." By FREDERIC HOLMWOOD, British Consul at Zanzibar.

APRIL 17.—"The Parsis and the Trade of Western India." By JEHANGEER DOSABHOY FRAMJEE.

MAY 8.—"The Ancient and Modern Methods of Treating Epidemics of Small-pox in Japan." By ROBERT PRINGLE, late Sanitary Department H.M. Bengal Army.

MAY 15.—

FOREIGN AND COLONIAL SECTION.

Tuesday evenings at Eight o'clock.

JANUARY 27.—"With the British Association to the Canadian North-West." By STEPHEN BOURNE.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings at Eight o'clock.

FEBRUARY 12.—"Production of Ammonia from the Nitrogen of Minerals." By GEORGE BEILBY.

FEBRUARY 26.—"Tempered Glass." By Dr. FREDERICK SIEMENS.

MARCH 12.—"Recent Improvements in Photographic Development." By W. K. BURTON.

APRIL 23.—"The Chemistry of Ensilage." By FREDERICK J. LLOYDD.

The dates given above are subject to alteration.

Cantor Lectures.

Monday Evenings at Eight o'clock.

The Second Course will be on "Climate, and its relation to Health." By G. V. Poore, M.D.

Lecture II. Jan. 19.—The effects of Soil, Drainage, and Vegetation upon Climate.

Lecture III. Jan. 26.—The chief sources of Atmospheric Impurities, both Inorganic and Organic. Climatic Diseases and Climatic Health Resorts.

Howard Lectures.

Thursday evenings at Eight o'clock:—

The fourth lecture of the Special Course delivered under the Howard Trust, on "The Conversion of Heat into Useful Work," by W. Anderson, M.Inst.C.E., will be delivered on January 22; Lecture V. on January 29; and Lecture VI. on February 5.

Admission to Meetings.

Members have the right of attending all the Society's meetings and lectures. Special tickets are required for the Juvenile Lectures. Every member can admit *two* friends to the Ordinary and Lectural Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the members, but admission can also be obtained on the personal introduction of a member.

MEETINGS FOR THE ENSUING WEEK.

Monday, Jan. 19...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. G. V. Poore, "Climate, and its Relation to Health." (Lecture II.)

East India Association, Council Room, Exeter Hall, Strand, W.C., 3 p.m. Mr. A. K. Settna, "The Age of Competition for the Indian Civil Service."

British Architects, 9, Conduit-street, W., 8 p.m. Mr. W. White, "The Fireproof Closing of Openings in Party Walls under the Metropolitan Building Act."

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m. Rev. Dr. G. U. Pope, "The South-Indian Vernaculars."

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. H. H. Statham, "Form and Design in Music."

Tuesday, Jan. 20...Royal Institution, Albemarle-street, W., 3 p.m. Prof. H. N. Moseley, "Colonial Animals, their Structure and Life Histories." (Lecture II.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. A. Hamilton-Smythe, "A Comparison of British and Metric Measures for Engineering purposes."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m. Dr. Robert Giffen, "Further Notes on the Progress of the Working Classes."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. C. Pelsener, "The Coxal Glands of *Mygale*." 2. Mr. E. J. Sidebotham, "The Myology of *Chironectes yapock*.'" 3. Mr. G. A. Boulenger, "Description of a new Species of Frog from Asia Minor." 4. Dr. O. Boettger, "Five new Species of the Genus *Buliminus* from the Levant, from the Collection of Vice-Admiral T. Spratt."

Wednesday, Jan. 21...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. D. Pidgeon, "Labour and Wages in the United States."

Meteorological, 25, Great George-street, S.W., 7 p.m. Annual Meeting and Address by the President.

Entomological, 11, Chandos-street, W., 7 p.m. Annual Meeting.

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. H. Syer Cuming, "St. Milburga, Abbess of Wenlock." 2. Mr. C. Lynam, "Notes of the Inscription on the Carew Cross."

Thursday, Jan. 22...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Howard Lectures.) Mr. W. Anderson, "The Conversion of Heat into Useful Work." (Lecture IV.)

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 7 p.m. Professor C. Stewart, "Sketches of Marine Life." (Part III.)

Royal Institution, Albemarle-street, W., 3 p.m. Professor W. Dewar, "The New Chemistry." (Lecture II.)

Telegraph-Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. Inaugural Address by the President, Mr. C. E. Spagnoletti.

Friday, Jan. 23...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. E. C. Buck, "The Agricultural Outlook of India."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Prof. H. N. Moseley, "The Fauna of the Sea Shores."

Philological, University College, W.C., 8 p.m. Dr. J. A. H. Murray, "A Dictionary Evening."

Quekett Microscopical Club, University College, W.C., 8 p.m. Papers by Dr. W. B. Carpente and Mr. F. Parsons.

Clinical, 53, Berners-street, W., 8½ p.m.

Saturday, Jan. 24...Physical, Science Schools, South Kensington, S.W., 3 p.m. 1. Mr. E. Clemenshaw, "A Mode of Exhibiting the Spectra of certain Substances by Burning them in an Atmosphere of Oxygen." 2. Mr. Herbert Tomlinson, "A Theory concerning the Molecular Architecture of Solids, illustrated by experiments on the loss of energy of a wire vibrating tortionally."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Dr. Waldstein, "Greek Sculpture from Pheidias to the Roman Era." (Lecture II.)

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FRIDAY, JANUARY 23, 1885.

All communications for the Society should be addressed to Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Dr. Poore delivered the second lecture of his course on "Climate in its Relation to Health," on Monday evening, 19th inst. He began by alluding to the fact that the crew of the *Eira* enjoyed excellent health in the Arctic regions, under conditions which, in this country, or still more in the tropical countries, would be considered most mal-hygienic. The reason probably was that in the Arctic regions putrefaction and allied changes were impossible owing to the cold and dryness, and the diseases dependent on putrefaction were also impossible. Attention was drawn to the effect that most of the diseases which were fatal in tropical countries were connected with putrefaction and decay, and as instances of this, malarious diseases, yellow fever, and cholera, were brought forward. Since putrefaction depended upon the access of minute organisms to the putrescible matter, and since these organisms were found in the atmosphere as well as in the soil and water, a study of the floating matter in the air became most important. The air has been systematically examined in Paris and Berlin, and especially at the Observatory of Montsouris in the former city. Among floating bodies in the air were to be found spores of fungi, pollen, grains of starch, algæ, &c., besides mineral matters of great variety. Miquel, by means of cultivation experiments, had been at great pains to estimate the number of bacteria and allied micro-organisms in the air, and the result of his experiments shewed a striking connection between the density of population and the number of bacteria in the air. Thus, in each cubic metre of air there were found at the following stations the bacteria in numbers as follows:—In the high Alps the air was pure, absolutely free from bacteria; on the Lake of Thun, at an elevation of 560 metres, ·8; near the hotel of Thun, 2·5; in a room of the hotel, 60; in the park at Montsouris, 760; and in the Rue de Rivoli, 5,500. The largest numbers found were in the hospitals, where each cubic metre of air contained as a minimum 5,500, and as a maximum 28,000. In order that bacteria and other microbes may flourish, a suitable soil is necessary. Raulin's experiments with the *Aspergillus Niger* were explained. Raulin found that he could grow a uniform amount of aspergillus on a given area of a liquid of definite composition. This liquid contained (among other things) $\frac{1}{50000}$ part of zinc, and if the zinc were omitted, the crop of aspergillus fell to $\frac{1}{10}$ of the normal; and if $\frac{1}{1600000}$ of nitrate of silver were added, the fungus would not grow at all. This showed the importance of mineral ingredients in the composition of the "soil." and this fact helped in some measure to explain why it was that people seldom had the same fever twice. The reason being that the first attack exhausted the blood of something which was necessary for the growth of the organism upon which the fever depended.

The lectures will be published in the *Journal* during the summer recess.

SOCIETY OF ARTS' PRIZES.

The Council of the Society of Arts are prepared to award the following Gold Medals in connection with the International Inventions Exhibition:—

John Stock Prize.

Under the John Stock Trust, one Gold Medal, for the best application of Photography to a Permanent Printing Process, Group XXVI., Class 140; Group XXIX., Class 159.

Howard Prizes.

Under the Howard Trust, five Gold Medals, for the best exhibits (coming within the terms of the Trust*) in the following Classes:—One for the best exhibit in Group IV., "Prime Movers," Class 26. Steam - engines and

* The Trust was left "for the purpose of presenting periodically a prize or medal to the author of a treatise on the properties of steam generally, or any of them particularly, as applied to motive-power, or it may be of air or permanent gases, or vapours, or other agents so applied, or to the inventor of some new and valuable process relating thereto."

Boilers. One for the best exhibit in Group IV., Class 27. Gas and Air Engines. One for the best exhibit in Group IV., Class 28. Means of Utilising Natural Forces. One for the best exhibit in Group XI., Classes 59 to 62. One for the best exhibit in Group XIII., "Electricity," Class 72. Distribution and Utilisation of Power.

FOTHERGILL PRIZE.

Under the Fothergill Trust, one Gold Medal for the most novel and best exhibit in Group XXVIII., "Philosophical Instruments and Apparatus," Classes 148 to 158.

ALFRED DAVIS PRIZE.

Under the Alfred Davis Trust, three Gold Medals to be awarded in Division II. of the Exhibition (Music), Groups XXXII. to XXXIV., Classes 166 to 180.

The Council propose to ask the Juries in each Class to recommend for their consideration either two or three exhibits which they might consider deserving a prize. It will not be necessary for any special application to be made in respect of these Prizes.

A full list of the contents of the classes referred to above was given in the *Journal* of January 9th.

Proceedings of the Society.

SEVENTH ORDINARY MEETING.

Wednesday, January 21, 1885; The Hon. JAMES RUSSELL LOWELL, D.C.L., the American Minister, in the chair.

The following candidates were proposed for election as members of the Society:—

Donkin, W. F., Malvern-lodge, Upper Tulse-hill, S.W.
Dunn, Alexander Douglas, 19, Charterhouse-square, E.C.
Evans, Frederick Evans, Postal Telegraphs, Birmingham.
Lavender, John, 11, Todd-street, Manchester.
Lavender, John, jun., 201, Bury New-road, Manchester.
Morison, Arthur Duff, 23, Regency-street, Westminster, S.W.
Salt, Shirley Harris, M.A., 73, Queensborough-terrace, W.

The following candidates were balloted for and duly elected members of the Society:—

Barnett, William Hyde, 11, New Gravel-lane, Shadwell, E.
Dobbs, Samuel, 1, Sherriff-road, West Hampstead, N.W.
Ebner, Joseph Frederick, 15, Doughty-street, Mecklenburgh-square, W.C.
Janes, George F., The Laurels, New Southgate, N.
Leage, Richard William, Shenfield, 17, Carleton-road, Tufnell-park, N.
Mackinlay, Frederick, 36, Alsine, Buenos Ayres.
Mansfield, William H. Stanley, Richmond College, Surrey.
May, Oliver, The Gas Works, Plymouth.
Shepherd, James, 45, Via Stella, Milan.
Smith, John Nidd, 85, South-street, Greenwich, S.E.
Whitworth, Charles Henry Billingshurst, Godswell, Bloxham, near Banbury.

The paper read was—

LABOUR AND WAGES IN AMERICA.

BY D. PIDGEON.

The United States of America are, collectively, of such vast extent, and, singly, so individualised in character, that to speak of their labour conditions as a whole would be as impossible, in an hour's address, as to describe their physical geography or geology in a similar space of time. I shall, therefore, confine what I have to say this evening on the subject of labour and wages in America to a consideration of the industrial condition of certain Eastern States which, being essentially manufacturing districts, offer the best instances for comparison with the labour conditions of our own country. That this field is of adequate extent and of typical character may be inferred from the fact that the three States composing it, viz., New York, Massachusetts, and Connecticut, contain together nearly one-half of the whole manufacturing population of America, while Connecticut and Massachusetts are the very cradle of American manufacture, and the home of the typical Yankee artisan. In addition, the State of Massachusetts is distinguished by possessing a Bureau of Statistics of Labour, whose sole business is to ventilate industrial questions, and to collect such facts as will afford the statesman a sound basis for industrial legislation. We shall find ourselves, in the sequel, indebted for some of our chief conclusions to this excellent public institution.

If we ask ourselves, at the outset of the inquiry, "Who and what are the operatives

of manufacturing America?" the answer involves a distinction which cannot be too strongly insisted upon, or too carefully kept in mind. These people consist, firstly, of native-born, and, secondly, of alien workers. The United States census, reckoning every child born in the country as an American, even if both his parents be foreigners, would make it appear that only six and a half millions out of its fifty millions are of alien birth, but, for our purpose, these figures are misleading. There is a vast difference, in many important respects, between "Americans" derived from a stock long settled in the States, and "Americans" with two, or even with one alien parent. In the former case, the hereditary sense of social equality, the teaching of the common school, and the influence of democratic institutions, produce a certain type of character, which I distinguish by the epithet "American" because it is of truly national origin. In the latter case, the so-called "American" may be really a German, an Irishman, an Englishman, or a Swede, but the qualities which I would distinguish by the word "American" have not yet been developed in him, although they will probably be exhibited by his later descendants.

Setting the census figures aside, therefore, we find, from the Registration Reports of Massachusetts, that fifty-four out of every hundred persons who die within the limits of this State are of foreign parentage. Now, bearing in mind that Massachusetts is essentially a Yankee State, where comparatively few European emigrants settle, it seems probable that, going back several generations, the numbers, even of Massachusetts men, who may be truly called "Americans," would dwindle considerably. These men, however, the children of equality, of the common school, and of democratic institutions, may be considered as leaven, leavening the lump of European emigration, and shaping, so far as they can, the character of the American people that is yet to be.

Native American labour is best described by reference to a recent past, when it filled all the factories of the United States, and challenged, by its high tone, the admiration of Europe. At the beginning of this century, public opinion in America was most unfriendly to the establishment of manufactories, so great were the complaints of these made in Europe as seats of vice and disease. Thus, when Humphreysville, the first industrial village in America, was built, in 1804, by the Hon. David Humphreys, who wished to see the colony independent of the mother country for her supplies of manufactured goods, parents refused to place their children in his factories until legislation had first made the mill-owner responsible both for the education and morality of his operatives. Similarly, when the cotton mills of Lowell, and the silk mills of Hartford, began to rise, between 1832 and 1840, the American people held the capitalist responsible for the moral, mental, and physical health of the people whom he employed, with the result that all England wondered at the stories of factory operatives, and their so-called "refinements," which were given to this country by writers like Harriett Martineau and Charles Dickens.

Lowell, between the years 1832 and 1850, was, perhaps, the most remarkable manufacturing town in the world. Help, in the new cotton mills, was in great demand, and what were then thought very high wages were freely offered, so that, in spite of the national prejudice against factory labour, operatives began to flow from many quarters into the mills. These people were, for the most part, the daughters of farmers, storekeepers, and mechanics; of Puritan antecedents, and religious training. In the mill they were treated kindly, and, although their hours were long, they were not overworked. A feeling of real, but respectful, equality existed between them and their employers, and the best hands were often guests at the houses of the mill-owners or ministers of religion. They lived in great boarding-houses, kept by women selected for their high character, and it is of these industrial families, and of their refined life, that observers like Dickens, Lyell, and Miss Martineau spoke with enthusiasm. The last writer has made us acquainted, in her "Mind among the Spindles," with the height to which intellectual life once rose in Lowell mills, before the wave of Irish emigration, following on the potato famine, swept native American labour away from the spindles. The morality of the early mill-girls, again, was practically stainless, and, strict as the rules of conduct were in the factories, these were really dead letters, so high was the standard of behaviour set and sustained by the mill-hands themselves.

Such was the character of native American labour, less than forty years ago, and such, almost, it still remains in those, now few, centres of industry where it has been little diluted with a foreign element. Nowhere is this so conspicuously the case as in Massachusetts and Connecticut,

and especially in the western valleys of the former State, where important mill-streams, such as the Housatonic, the Naugatuck, and the Farmington, are lined with mills still largely manned by native Americans.

Aside from wages, which will be separately considered, the housing, education, sobriety, and pauperism of any given industrial community form together the best possible test of its social condition. In regard to the housing of labour, there is no more important fact to be discovered than the proportion of an operative population who possess in fee simple the houses in which they dwell. This proportion among the wage-earners of Massachusetts is remarkably high, one working man in every four being the proprietor of the house in which he lives. Of the remaining three-fourths, 45 per cent. rent their houses, and 30 per cent. are boarders. With regard to inhabitancy, the average number of persons living in one house in Massachusetts is rather more than six, while the average number of the Massachusetts family is four and three quarter persons. Hence, lodgers being excepted, almost every operative family in this State lives under its own roof, while one fourth of all such roofs are owned by the heads of families dwelling therein.

I leave, for a moment, the agreeable task of describing one of these homes of native American labour, and pass on to the question of education, whose universality among native Americans is perhaps most vividly illustrated by the following facts. Of 1,200 persons born in Massachusetts, whether of native or foreign parents, only one is unable to read or write, while four Germans and Scotch, six English, twenty French Canadians, twenty-eight Irish, and thirty-four Italians, out of every 100 emigrants of these nationalities respectively are illiterate. The total number of public, elementary, and high schools in the United States is 225,800, or about one school for every 200 of the entire population, and one for, say, every fifty of the 10,000,000 pupils who attended school during the census year of 1880. Finally, referring once more to Massachusetts, there are nearly 2,000 free libraries in this single State, or one to every 800 inhabitants, and these, together, own 3,500,000 volumes, and circulate 8,000,000 of volumes annually.

With regard to sobriety, it is well known that local option succeeds in closing the liquor saloons in very many operative American towns, and with the happiest results. The county of Barnstaple in Massachusetts, for example, with a population of 32,000 souls, and having no licensed liquor saloons, yields a crop of only three convictions per annum for drunkenness. The county of Suffolk, on the other hand, with a population of nearly 400,000, and a license for every 175 of its inhabitants, acknowledges one drunkard for every 50 of its population. The labour, in one case, is nearly all native; in the other, largely foreign.

It is almost, if not quite, impossible to obtain the statistics of pauperism in America. The "indoor" poor, as paupers in almshouses are called, can be found and counted with comparative ease, but how can the out-door paupers be found? It is no use inquiring for them from door to door, and the poor-master's disbursements are so limited in amount that his bills for pauper relief become mixed up with other items, so that they cannot be separately stated. The total number of paupers resident in American almshouses is 67,000, or about one in every 70,000 of the whole population. In England, we have still one pauper in every fifty thousand of the population. Such being the more important aspects of native American labour, as displayed by the statistician, it is time for the social observer to give his account of a typical American artisan's home.

We are at Ansonia, in the Naugatuck valley, one of the chief towns of "Clockland," where, within a radius of twenty miles, watches and clocks are made by millions and sold for a few shillings apiece. Our friend, Mr. S., is an Ansonia mechanic who occupies a house with a basement of cut stone, and a tasteful superstructure of wood, having a wide verandah, kitchen, parlour and bedroom on the ground floor, and three bedrooms above. The house is painted white, adorned with green jalousies, and surrounded by a well-tilled quarter-acre lot. Its windows are aglow with geraniums, and, from its verandah we glance upwards to the wooded slopes of the Green Mountain range, and downwards to the River Naugatuck, whose blue mill-ponds look like tiny Highland lakes surrounded by great factories. Within, a pleasant sitting-room is furnished with all the comforts, and some of the luxuries of life, the tables are strewn with books, and the walls decorated with pretty photographs. Mr. S.'s wife and daughter are educated and agreeable women, who entertain us, during an hour's call, with intelligent conversation, which, turning for the most part on the events of the War of Independence, is characterised by ample historical knowledge, a logical habit

of mind, and a remarkable readiness to welcome new ideas. No refreshments are offered us, for no one eats between meals, and, in private houses, as in the public refreshment rooms, where native labour usually takes its meals, nothing stronger than water is ever drunk. Such are the homes of men whom I would distinguish as "American" artisans, and such, also, are those of many foreign workmen who have been long under native influence.

It is not in the valleys of Massachusetts, however, that the greatest manufacturing cities of the Union are to be found, the towns already referred to containing usually only a few thousand inhabitants, and being still, for the most part, rural in their surroundings. They are, indeed, the fastnesses, so to speak, to which the Yankee artisan has retired, after having been almost literally swept out of the great manufacturing cities by successive waves of emigrant labour, chiefly of Irish and French-Canadian nationality. To these greater cities we must now turn for examples of a condition of operative society which contrasts most unfavourably with that which has already been sketched; it being, meanwhile, understood that a penumbral region, of more or less mixed conditions, graduates the brightness of the one into the darkness of the other picture.

The city of Lowell, whose brilliant past is so well known, exemplifies, on that very account, better than any other manufacturing town in the States, the character of recent alterations in American labour conditions. The mill-hands, formerly such as I have described them, have been almost entirely replaced by Canadians and Irish, who have given a new character and aspect to the Lowell of forty years ago. "Little Canada," as the quarter inhabited by the former people is called, exhibits a congeries of narrow, unpaved lanes, lined with ricketty wooden houses, which elbow one another closely, and possess neither gardens nor yards. They are let out in flats, and are crowded to over-flowing with a dense population of lodgers. Peeps into their interiors reveal dirty, poorly furnished rooms, and large families, pigging squalidly together at meal times, while unkempt men and slatternly women lean from open windows, and scold in French, or chatter with crowds of ragged and bare-legged children, playing in the gutters.

The Irish portion of the town has wider streets, and houses less crowded than those of "Little Canada," but is, altogether, of scarcely better aspect. Slatternly women gossip in groups about the doorways. Tawdrily dressed girls saunter along the side walks, or loll from the window-sills. Knots of shirt-sleeved men congregate about the frequent liquor-saloons, talking loudly and volubly. No signs of poverty are apparent, but everything wears an aspect of prosperous ignorance, satisfied to eat, drink, and idle away the hours not given to work. Such is the general aspect of operative Lowell to-day; but some of the old well-conducted boarding-houses remain, sheltering worthy sons and daughters of toil. Similarly, the outskirts of the city are adorned with many pretty white houses, where typical American families are growing up amidst wholesome moral and physical surroundings, and enjoying all the advantages of schools, churches, libraries, and free institutions which the Great Republic puts everywhere, with lavish profuseness, at the service even of its least promising populations.

Concerning the Lowell mill-hands of to-day, I prefer, before my own observations, to quote from an article entitled "Early Factory Labour in New England," written by a lady, herself one of the early mill girls, and published in the "Massachusetts Labour Bureau Report for 1883." She says:—

"Last winter, I was invited to speak to a company of the Lowell mill girls, and tell them something of my early life as a member of their guild. When my address was over, some of them gathered round and asked me questions. In turn, I questioned them about their work, hours of labour, wages, and means of improvement. When I urged them to occupy their spare time in reading and study, they seemed to understand the need of it, but answered, sadly, 'We will try, but we work so hard, and are so tired.' It was plain that these operatives did not go to their labour with the jubilant feeling of the old mill-girls, that they worked without aim or purpose, and took no interest in anything beyond earning their daily bread. There was a tired hoplessness about them, such as was never seen among the early mill-girls. Yet they have more leisure, and earn more money than the operatives of fifty years ago, but they do not know how to improve the one or use the other. These American-born children of foreign parentage are, indeed, under the control neither of their church nor their parents, and they, consequently, adopt the vices and follies instead of the good habits of our people. It is vital to the interests of the whole community that they shonld be brought under good moral influence; that they should live in better homes, and breathe a better social atmosphere than is now to be found in our factory towns."

The City of Holyoke, another great cotton centre, having 23,000 inhabitants, is in some

respects the most remarkable town in the State of Massachusetts. It was brought into existence, 35 years ago, by the construction of a great dam across the Connecticut River; and, around the water-power thus created, mills have sprung up so rapidly that the population, whose normal increase is eighteen per cent. every ten years in Massachusetts, has doubled, during the last decade, in Holyoke. But eighty out of every 100 persons in the city are of foreign extraction, the prevailing nationality being French-Canadian, a people who are so rapidly displacing other operatives, even the Irish themselves, in the manufacturing centres of New England, that they must not be dismissed without remark.

The Canadian-French were recently described in a grave State paper as a "horde of industrial invaders," and accused of caring nothing for American institutions, civil, political, or educational; having come to the States, not to make a home, but to get together a little money, and then to return whence they came. The parent of these immigants is the Canadian *habitan*, a peasant proprietor, farming a few acres, living parsimoniously, marrying early, and producing a large family, who must either clear the soils of the inclement north, or become factory operatives in the States. They are a simple, kindly, pious, and cheerful folk, with few wants, little energy, and no ambition; ignorant and credulous, Catholic by religion, and devoted to the priest, who is their oracle, friend, and guide in all the relations of life. Such are the people—a complete contrast with Americans—who began, some twelve years ago, to emigrate to the mills of New England. They came, not only intending to return to their own country with their savings, but enjoined by the Church to do so. Employers, however, soon found out the value of the new comers, and Yankee superintendents preferred them as operatives before any other nationality, not only on account of their tireless industry and docility, but because they accepted lower wages, and kept themselves clear of trade-union societies. Thus, finally, it has come about that nearly 70 per cent. of the cotton operatives of Holyoke are of French-Canadian origin, and the social condition of all these people is precisely similar to that which has already been described as characterising the inhabitants of "Little Canada" in Lowell.

It has already been said that the average rate of inhabitancy is six persons per house in the State of Massachusetts, but the presence of the French in Holyoke actually doubles the inhabitancy of the whole town, with what effect upon their own special quarter may easily be imagined. Probably, nowhere in Europe could there be found more crowded houses, and worse physical conditions of life, than in the quarters inhabited by certain alien operatives in many manufacturing towns of the United States.

Sharp contrasts as they are, these sketches fairly picture the heights and depths of industrial conditions in a region which, as I would again remind you, contains nearly one-half of all the factory operatives in America. More than this, while the States in question would yield to no others their claims to represent advanced civilisation, Massachusetts, the creation of the Puritan refugees, and the cradle of American independence, stands confessedly at the head of all her sister States for enlightened philanthrophy. There are no greater lovers of right, honourers of industry, and friends to education in the world than its people, yet the present social condition of Holyoke and of Lowell, as of many other manufacturing cities, would have shocked all America thirty years ago, and been impossible less than half a century back. It is time we should ask—how is America going to treat a problem, formerly the danger and still the perplexity of Europe, for which democratic institutions have failed to furnish the solution, once confidently, but unfairly, expected from them?

The State, the Church, and the School are all doing their best to prevent the lapse to lower conditions which seems to threaten labour in the States, each of them trying their utmost to "make Americans" of alien labourers, by means of the political, religious, and educational institutions of the country. How inadequate these unaided agencies are for the accomplishment of their gigantic task is nowhere so clearly realised as in the common, or free, schools of the States. These, in districts such as I have distinguished as "American," are filled with boys and girls, of all ages from five to eighteen, whose appearance and intelligence bespeak high social conditions. Whatever the occupations which these young people may ultimately adopt—and all of them are destined for work-a-day lives—an observer feels quite sure that they are more likely to raise the character of their several employments, than to be themselves degraded to lower social levels, on quitting school.

But no similar confidence in the future of

American labour is engendered by visits to the schools where sits the progeny of alien labour. In the case of the Canadians, indeed, parents and priests alike bend all their energies to the establishment of "parochial schools," which, if they forward the cause of the Church, do little for education in the American sense of requiring good citizens, even more than good scholars, at the hands of the national teachers.

The primary schools of great industrial towns, such as Fall River, the Manchester of America, are filled, to quite as great an extent as similar schools in Europe, with ignorant, ragged, and bare-footed urchins. These children are, indeed, no less well cared for and taught than their Yankee fellows, and one cannot sufficiently admire the energy and enthusiasm with which school-teachers generally endeavour to "make Americans" of their stolid and ragged little alien charges. In these cases, however, where often the children have had no schooling at all before they are old enough to work, it is quite clear that the school cannot do all that is required to raise the labour of to-day up to the levels it occupied in the past. And, if the school itself is ineffective in this regard, how much more so must be the Church, to which immigrant youth is a comparative stranger; or those democratic institutions which are based, to quote the words of Washington himself, upon "the virtue and intelligence of the people."

Whether the present condition of labour in America will ever again be lifted to the levels of the past depends, in truth, less upon the State, the Church, and the School, than upon the part which the American employer is taking, or about to take in this question. It is impossible for any unprejudiced observer to be long in the States, and especially in the New England States, without coming to the conclusion that a large number of employers are very anxious about the character of the labour they employ, and willing to assist to the utmost of their power in improving it. In spite of the love of money and luxury which is so conspicuous a feature of certain sections of American society, a high ideal of the proper function of wealth has arisen in the States, where large fortunes are chiefly things of recent date, among large and influential classes having an enlightened regard for the best welfare of the country. This regard finds expression now in the establishment of a factory, managed with one eye on profits and another on the elevation of the artisan, and now in the endowment of free libraries or similar institutions, offering opportunities of improvement to all.

To give only a few instances of the former movement; Mr. Pullman, the great car-builder, has recently established, on Lake Calumet, a vast system of workshops and workmen's homes, a description of which reads like a chapter from More's "Utopia." The Waterbury Watch Company has lately built a factory, employing 600 hands, on similar lines to those of Mr. Pullman. Cheney Brothers' silk mills at South Manchester remain now, after Irish labour has entirely taken the place of native hands, at almost the same high level as that which, in common with Lowell, they held forty years ago. Messrs. Fairbanks, of St. Johnsbury, in Vermont, conduct a large establishment, where every married *employé* owns a house in the village, almost an Eden for beauty and order, which has grown up around these remote but remarkable scale works. Similarly, the Cranes at Dalton, in Massachusetts; Messrs. Brown, Sharpe and Co., at Providence, Rhode Island; Mr. Hazard at Peacedale, Narragansett; and last, not least, Col. Barrows, at Willimantic, in Connecticut, have all succeeded in restoring the past conditions of native American labour among operatives, now, for the most part, of alien origin.

I wish that time permitted me to sketch, however briefly, the mills to which I have last alluded. It must suffice to say that the devoted labours of Col. Barrows, President of the Willimantic Thread Co., have succeeded in creating, out of Irish labour, social conditions of industrial life which approach ideal perfection as nearly as the work of imperfect man can possibly do. And, better still, the high morality and intelligence of Col. Barrow's 1,600 operatives, the comfort and seemliness of their homes, the cleanly and cheerful character of the mill work, even the refinements of the music and art schools attached to the mill, can be proved, by hard figures, to be paying factors in the undertaking, viewed from a purely commercial standpoint.

So far, I have endeavoured to show that a great contrast exists between what once was, and now is, the condition of factory labour in America. I have, further, described certain survivals of an earlier and happier state of things, and indicated the forces now at work tending to lift the Holyoke of to-day, for

example, to the social levels of old Lowell. I have given my reasons for believing that the democratic institutions of America are incapable, unaided, of accomplishing such a task as this change implies, and concluded that its accomplishment depends mainly on the action of the American employer. What this action as a whole, and what, therefore, the future of labour in America is likely to be, I confess myself in grave doubt—doubt from which I turn, with something like a sense of relief, to discuss those economical considerations affecting wage-earners which have hitherto been made to give place to social inquiries.

We have now to ask what are the wages of labour in the States, their relation to the cost of subsistence, and to wages and cost of subsistence in our own country? Finally, I shall briefly consider certain propositions of the American political-economist which are so inextricably mixed up with the question of labour and wages in the States, that it is impossible to discuss the one without taking some note of the other.

Until quite recently, no complete investigation, bringing the rates of wages paid in industries common to the United States and European countries, has ever been made, although the results of such an investigation have been constantly and earnestly called for both by the press and people of America. Permit me to remark, in passing, that we know little in this country of the desire for full, trustworthy and accessible statistics, concerning all matters of national interest, which dominates the public mind of America; and as little of the willingness with which American citizens of all classes place the particulars of their private business at the service of the statistician. This desire for statistical bases whereon the statesman and economist may build, is vividly illustrated by that publication, perhaps the most wonderful in the whole world, entitled a "Compendium of the Census of the United States" issued with every decade. These volumes, accessible to everybody, and arranged with marvellous skill and lucidity, offer to the social observer a complete, accurate, and suggestive survey of every field comprised within the vast domain of the national interests. An evening's address would not more than suffice to indicate the scope and appraise the value of this work, which is a mine wherein, the ore ready dressed to his hand, the politico-economic or industrial essayist might work for years without exhausting its riches.

But the United States Census does not treat specifically of wages and subsistence, and it is to the Massachusetts Labour Bureau that we must again turn for such information as we now require. Dr. Edward Young, indeed, the late chief of the United States Bureau of Statistics, published an elaborate work upon this subject in 1875, but his comparisons as to the relative cost of living in America and Europe, good in themselves, are rendered of little value by the absence of such statistics as would give the true per-centage of difference between American and foreign wages. Several elaborate wages reports were also published between 1879 and 1882, which, while they gave the American side of the question with great fulness, presented foreign wages very incompletely.

Always, however, impressed with the importance of making an accurate comparison between wages and the cost of subsistence on the two sides of the Atlantic, but unable to undertake a very wide inquiry with the funds at its disposal, the Massachusetts Bureau determined, in the fall of 1883, upon reducing to narrower limits than heretofore the field of investigation. Instead of America and Europe, Massachusetts and Great Britain were selected for comparison, the former as the chief manufacturing State of America, the latter as her leading competitor.

With this view, a number of agents were sent to gather personally, from the pay rolls of American and English manufactories, the rates of wages paid in twenty-four of the leading industries which are common to the two districts respectively. It was, at first, sought to extend the inquiry to thirty-five different industries, a number which would practically have covered the whole ground, but nine of these were finally abandoned for want of sufficient British information.

It is a perfectly easy thing, as already indicated, to gather wage or other statistics in the counting-houses of Massachusetts manufactories, but quite a different matter when a collection of similar information is attempted in this country, where most proprietors are unwilling, and many altogether refuse, to give any information regarding their industries.

The following Table, of which an enlarged facsimile, marked A, appears on the wall, specifies the twenty-four industries from which the returns in question were made, and the number of establishments making such returns in each industry in either country:—

TABLE A.

Industries.	Massachusetts.	Great Britain.	Totals.
Agricultural implements	4	1	5
Artisans' tools	3	4	7
Boots and shoes	18	2	20
Brick	3	1	4
Building trades	32	24	56
Carpetings	1	1	2
Carriages and waggons	11	3	14
Clothing	10	4	14
Cotton goods	10	9	19
Flax and jute goods	2	3	5
Food preparations	5	2	7
Furniture	11	1	12
Glass	1	3	4
Hats (fur, wool, and silk)	3	2	3
Hosiery	5	3	8
Liquors (malt and distilled)	10	1	11
Machines and machinery	12	15	27
Metals and metallic goods	25	13	38
Printing and publishing	12	7	19
,, dyeing, bleaching, &c.	3	4	7
Stone	10	1	11
Wooden goods	12	1	13
Woollen goods	4	2	6
Worsted goods	3	3	6
	210	110	320

Thirty-two cities in Massachusetts, and twenty-six in Great Britain, were visited in search of returns, of which almost all our great industrial centres yield their quota.

It being, of course, impossible to obtain wage returns for all the *employés* of these various industries in either country, the investigation aimed at covering at least 10 per cent. of such totals, and, in the case of Massachusetts, succeeded in getting returns for 36,000 hands, or 13 per cent. of the whole number of artisans employed in the twenty-four industries examined. Great Britain on the other hand, made returns for about half that number of hands, but their proportion to the totals employed cannot be similarly stated, first, because, we have here no specific industrial census, and, second, because many of the English returns were made for an indefinite number of *employés*.

The comparison was made in the following way :—For each of the twenty-four industries, a table, consisting of four sections, was constructed, viz., "Occupation," "Aggregation," "Recapitulation," and "Comparison." The first gave the names of the various branches of each industry, classifying these as minutely as possible, because the names indicating subdivisions of labour are, generally, so different in the two countries, that the actual "matching" of occupations, desirable for a perfect comparison, is impossible. The second, or "Aggregation" section, brings the various occupations in the same industry into juxtaposition, and supplies opportunities for direct comparison. The third, or "Recapitulation" section, is drawn from the "Occupation" section, and shows the number of men, women, young persons, and children for whom wages are given ; whether these are paid by the day, or by piece ; and whether the wage returns show the actual amounts paid to a definite number of *employés*, or an average wage for a definite, or an indefinite number of *employés*. The fourth, or "Comparison" section, brings the highest, lowest, and general average weekly wages into final comparison.

The first three sections of the table, being either simply enumerative or collective in character, are easily understood without illustration, but an example of the "Comparative" section, marked Table B., hangs on the wall, and shows all the final comparisons at a glance.

TABLE B.

Classification.	1 Massachusetts.	2 Great Britain.	3 Massachusetts.	4 Great Britain.
Average highest weekly wage paid to—	dols.	dols.	dols.	dols.
Men	37·00	13·39	25·41	11·36
Women	5·50	...	8·57	4·10
Young persons	7·00	3·65	6·94	3·04
Children	5·70	...	4·64	1·05
Average lowest weekly wage paid to—				
Men	7·60	3·21	7·09	4.72
Women	5·00	...	4·62	2·27
Young women	4·50	1·46	4·26	1 66
Children	3·00	...	3·09	·60
Average weekly wages paid to—				
Men	12·04	8·07	11·85	8·26
Women	5·12	...	6·09	3·37
Young persons	5·76	2·52	5·10	2·40
Children	5·31	...	3·81	·79
General average weekly wage paid to all *employés*	11·75	8·07	10·32	6·96
RESULT : — General average weekly wages higher in Massachusetts by per cent.	45·60 per cent.		48·28 per cent.	

The two first columns of the table are simply illustrative of the method applied to a single industry, exhibiting the highest average,

lowest average, and average weekly wages, whether to men, women, young persons, or children, in the particular business of "Machine-making," together with the general average wages paid to all the *employés* in such industry. The general average weekly wages in this industry are thus shown to be 45·6 per cent. higher in Massachusetts than in Great Britain.

The 3rd and 4th columns of the table consolidate all the twenty-four industries, and yield, in similar terms, as in the case of machine-making, an average comparison applying to the whole group of industries under examination, giving, as a grand result, that the general average weekly wages of Massachusetts are higher by 48·28 per cent. than those of Great Britain.

It is, however, explained that the British wage-returns were made in three different ways, viz., for a definite number of *employés*; by per-centage returns, and by general returns; both of the latter being for an indefinite number of *employés*. Where more than one wage-basis was given, the highest figure was used in the calculations, and, this being the case in eighteen out of the twenty-four industries, its effects on the grand result are considerable; for, by crediting Great Britain with the *average* instead of the *high* weekly wage, the average per-centage in favour of Massachusetts rises from 48·28 per cent. to 75·94 per cent.

In order truly to indicate the higher per-centage of average weekly wages in Massachusetts, we must, therefore, agree upon a figure somewhere between these two extremes, viz., that of 48·28 per cent., derived from tables in which Great Britain is credited with the high wage, and that of 75·94 per cent., derived from those tables in which she is credited with the average of the returns made upon the different bases. The mean of these figures is 62·11 per cent., which is considered to be the result of the investigation, and may be formulated as follows:—The general average weekly wages paid to *employés* in twenty-four manufacturing industries common to Massachusetts and Great Britain, is 62 per cent. higher in the former, than the general average weekly wages paid in the same industries in the latter country.

But the question of wages forms only one side of the working man's account; on the other stands the cost of living, and no comparisons of prosperity, in given industrial communities, are of any value which omit to take into consideration the relative ease with which such communities can procure the means of subsistence. Table C presents a summary of prices, gathered in 1883, of the chief items in a working man's expenditure, and their cost in Massachusetts and Great Britain.

TABLE C.

Articles.	Per-centage higher in Mass.	Per-centage higher in Gt. Britain.
Groceries	16·18	—
Provisions	—	20·00
Fuel	104·98	—
Dry goods	13·26	—
Boots and shoes	42·75	—
Clothing	45·06	—
Rents	89·62	—

Having agreed that wages are probably 62 per cent. higher in Massachusetts than in Great Britain, it would be easy, if we could ascertain what proportion of a working man's income is spent respectively in groceries, provisions, clothing, &c., to determine what advantage an operative derives from the higher wages of the United States. Dr. Engel, the chief of the Prussian Bureau of Statistics, puts us in possession of this information, and, as the result of a laborious inquiry, has formulated a certain economic law which governs the relations between income and expenditure. From him we learn (see Table D) that—

TABLE D.

A working man with an income of £60 per annum spends as follows:—

	Per cent. of income.			Shillings
1. On Subsistence	62	or	Meat	248
			Groceries	496
2. ,, Clothing	16	,,		192
3. ,, Rent	12	,,		144
4. ,, Fuel	5	,,		60
3. ,, Sundries	5	,,		60
			Total shillings	1,200
				Or £60.

Now, referring to Table C, it will be seen that the same man's expenditure in America would be:—

		Shillings.		s.
1. Subsistence	Meat	248 −	20 p.c. =	198·4
	Groceries	496 +	16 ,, =	575·3
2. Clothing		192 +	45 ,, =	278·4
3. Rent		144 +	89 ,, =	272·1
4. Fuel		69 +	104 ,, =	122·0
5. Sundries		60 +	50 ,, =	90·0
			Total	1,536·2
				Or £76 16s.

In other words, a workman earning £60 per annum in Great Britain would receive £99, or 62 per cent. more wages in the States, but living there would cost him £77, or £17 more than here, giving him a net advantage of only 28 per cent., instead of 62 per cent., derived from living and working in America.

But this result does not exhaust the question. The standard of life is very different among working men in the States and in Great Britain, and the almost inexhaustible statistics of the report, already so often quoted, enable us to gauge this difference with accuracy. It has been proved, by a recent investigation, whose details we need not follow, that the expenditure of working men's families, of similar size, in Massachusetts, and in Great Britain, stand to each other in the ratio of 15 to 10. By introducing this new factor into our calculations, we find that a man who spends £60 per annum in England would spend £90, instead of £77, per annum in the States, paying American prices for subsistence, and living up to American standards. In other words, he would be a gainer to the extent of only £9 per annum by living and working in the United States. Finally, if we presume that 48 or 50 per cent., rather than 62 per cent., measures the higher wages of Massachusetts, the same man's increased wages would be £90 instead of £99, and he would neither lose or gain in money by becoming an American citizen, and adopting American habits.

That these conclusions agree with those rough and ready practical illustrations which, without being scientific, are generally trustworthy, let the following story evidence. Some years ago, a skilful moulder, in my then firm's employ, left us for the States, where he permanently settled. After a long absence, he returned for a few weeks' holiday, when I asked him whether he earned higher wages and found life more agreeable in America than in England. "Well, as to money" was his reply, "I think, taking all things into consideration, I did about as well in the old shop as I do now; but, socially speaking, I am somebody there, while here I am only a moulder." Social advantage, indeed, probably measures almost all the difference between the position of a skilled factory operative in the States and in England.

Let me not seem, however, to undervalue that difference. Statistics, after all, do not dominate human nature; on the contrary, human nature determines the statistician's figures. Every artisan emigrant to America gains opportunities of advancement of which his European fellows know nothing. If he have brains, the way to success is open there, while it is practically barred to anything short of genius for men of his class in Europe. Our Australian colonies, where unskilled labour can earn 7s. 6d. a day, and live for a trifle, are, indeed, a paradise for the mere wage-earner, who can scarcely help becoming also a wage-saver; but America is the country which, with wage conditions such as I have attempted to pourtray, still offers the best possible opportunities of success, and even of great careers, to clever working-men, and especially to clever mechanics. That man, however, is not worthy of a home in the Great Republic who does not appreciate the higher social levels at which native labour desires to live, who is not anxious to make the most of the advantages which democratic institutions offer him, who does not, in short, ardently desire to become a "good American."

There remains the question, already alluded to as inextricably bound up with American labour problems:—How does the American tariff affect wages? The idea that these are determinable by the tariff is the corner stone of protection in the States. The artisan has been so sedulously educated to believe that the chief object of import duties is to protect him from falling into a ruinous competition with what is called the "pauper labour of Europe," that no movement on the part of workmen in the direction of free trade is ever likely to arise in America. I am not now about to argue the question of protection, except in so far as it relates to labour; but it may be remarked, in passing, that internal competition, rather than the people, is the enemy from whom the tariff will probably receive its death-blow in the future. Protection will ultimately break down by its own weight in the States. Production already exceeds demand, the cry for a "wider market" and for "raw materials free" is in every manufacturer's mouth; and if America upholds her protective legislation too long, the produce of her mills and factories will, by-and-bye, force its way, in spite of the tariff, into the open markets of the world, but it will be through the gate of national suffering.

Few people in this country are, I think, aware of the extraordinary fervour with which the doctrine that protection benefits labour is preached in the States. We are ourselves accustomed to hear the question of free trade argued only from the economic

standpoint, but this is by no means so commonly the case in America. I shall try, by paraphrasing certain recent addresses of an able personal friend and enthusiastic protectionist, to illustrate the position taken by those persons who advocate the tariff, not upon economic grounds, but in the avowed interests of labour.

Referring to the words "Free Trade," the speaker in question begins by asking, "What is the essential nature of that which we call trade?" And answers himself as follows .—

"The grim, ugly fact is that trade is a fight, the markets are battle-fields, the traders are gladiators, carrying on a true war around questions of values, with no care whether the opposing party or the community at large can afford that the trade is made. This contest is always going on, whether a lady buys a pair of gloves, or a syndicate corners Erie. Antagonism is so fixed an element of trade, and so often defeats the object it blindly follows, as to make laws which seek to mitigate the ferocity of the struggle, as welcome to the far-sighted man of business as they are to the fore-doomed victims of this relentless warfare."

On the other hand, competition is said to be a—

"Wonder-worker in developing energy in the strongest individuals, and massing wealth in masterful States; but, since competitive trading can never be wholly beneficent, it should be strictly controlled, in the interests of the toiling millions, who are too weak successfully to oppose its attacks:—The results of forcing on the naturally weak, by means of competition, hard and unequal bargains which are evaded by the strong, are appalling in their magnitude, dividing whole peoples permanently into castes, rich and poor, injuring the former by excess, and the latter by deprivation, making a nation strong in the trading instinct, and rich in accumulated wealth, but weak and poor in all its other parts. This abuse is saddest of all when, failing to be recognised as an evil, the doctrines of Free Trade are wrought into the policy and social life of a people."

Protective remedies for this state of things are introduced as follows:—

"Wherever the value of competition has been fully recognised, but supplemented by wise control of its energies, the results are excellent. This fact forms the foundation of our protective laws, whose very name 'protective' implies assailants; those hard bargains, to wit, driven on the fighting side of trade, under the motto 'let the fittest survive.' When a small army is attacked by a large one, it covers itself by earthworks. Similarly, where there are sheep, and wolves abound, the farmer puts up fences which effectually protect his flock; and, in the same way, tariffs are "forts," whence the artisan may hope successfully to defend himself against the attacks of his powerful and unscrupulous enemy, capital; or they may even be considered as a pistol, which a little fellow points at a big bully who threatens him with a thrashing."

Such are the arguments which are urged with great fervour, and immense effect, upon the American artisan, who fully and firmly believes that protection is the only agent capable of lifting his lot above those dreaded levels at which the "pauper labour of Europe" is universally believed to live.

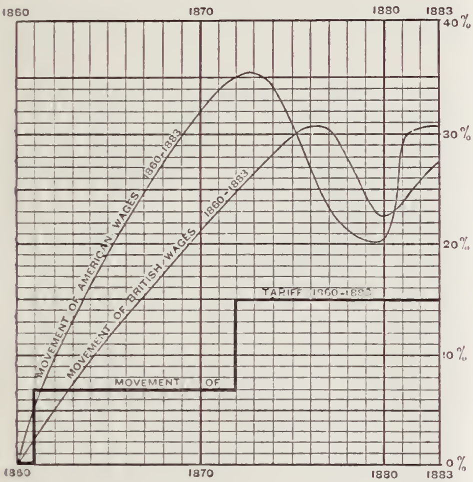
The simple answer to all this rhetoric appears to be that, while it might be valid as an indictment of the competitive system as a whole, it is valueless when directed against a part of that system only. Advocates who are not prepared to say that every bargain shall be controlled by beneficence, and who distinctly admire the chief results of competition, cannot logically demand that labour, alone of all saleable commodities, shall be bought and sold on altruistic principles.

In what immediately precedes, I have endeavoured to indicate the character of the pleadings, which make American artisans universally supporters of the tariff, and we must now return to the question:—What, after all, is really the effect of protection on wages in America? I answer that no legislative schemes can add to, although they may injure, the material resources of a State. Capital can only support the labour for which the annual harvest of such resources pays, and all that legislation can do is artificially to divert labour and capital from directions which they would take under the influence of natural laws.

America is selling, at the present time, about £160,000,000 worth of food and other raw products in Europe. These, together, represent her chief branch of business, in which nearly 50 per cent. of her population is engaged, and all this merchandise is sold in the Free Trade markets of the world. Wages in America, therefore, cannot possibly be regulated by the tariff, because, whatever wages can be earned by men engaged in the production of agricultural products—the prices of which are fixed in Liverpool—must be the rate of wages which will substantially be paid in other branches of business. Wages, like water, seek a level; if manufacture pays best, labour will quit agriculture; if agriculture pays best, manufactures will decline, and agriculture progress.

A glance at the condition of industrial society in America vividly illustrates this conclusion. Any man, with a few dollars and a strong pair of arms, can win far greater rewards from the soil than he could possibly obtain by the same effort in Europe. His wages are high, because the grade of comfort to be obtained from the land by means of a little labour is high, and the artisan's wages must follow suit, if men are to be tempted from the field into the workshop. American politicians, however, would have us believe that American labour owes its prosperity to taxation; in other words, that what the immigrant seeks is, not the rich prizes offered him by a free and fertile soil, but the blessings which flow from a tariff that adds an average 40 per cent. to the cost of everything he needs except food.

One more illustration, and I have done. Upon the wall hangs a diagram, which shows



the movements of American wages, of English wages, and of the tariff from 1860 to 1883. I have already argued that a tariff cannot determine wages, and the diagram affords positive proof that it has not determined them in America, as between 1860 and the present time. On the contrary, their movements are evidently due to the same causes as have influenced wages here during this period, while it is certainly remarkable that they have fallen sooner, fallen lower, and recovered less completely in America, where industry is "protected," than in Great Britain, where it is "unprotected."

Shortly to recapitulate all that has been advanced. I have endeavoured to show:—

1st. That a great change has occurred in the social condition of labour in the United States during the last forty years, and that, spite of all the existing agencies of improvement, it is doubtful whether the working classes of America are not, at the present moment, falling still further from those high ideals of operative life which once so brilliantly distinguished the United States from European countries.

2nd. That, although wages are probably some 60 per cent. higher in the chief manufacturing districts of America than in Great Britain, yet an English artisan would find himself little richer there than at home, after paying the enhanced prices for subsistence, and conforming to the higher standard of life which prevails in the States. At the same time, his whole social position and opportunities of advancement would be immensely improved.

3rd. I have tried to demonstrate that the tariff, to which the higher wages of America are so confidently attributed, has really no influence whatever upon them, and that it is not therefore an engine, such as it is glowingly represented to the American artisan, constructed for the purpose of raising his lot above that of the so-called "pauper labour of Europe." Any inquiry into the character of the work really accomplished by the engine in question, would lead me into regions of controversy forbidden in this room.

Finally, if I am asked why, in a review of American labour and wages, I have said nothing of trade unionism on the one hand, and of co-operative production on the other, I can only answer that to have introduced these among so many other interesting, but subsidiary, subjects which crowd around questions of labour and wages, would have doubled the volume of this address, and more than halved the patience with which you have kindly listened to it.

DISCUSSION.

Mr. Sedley Taylor asked if any steps had been taken in America to introduce the system of profit sharing, by which, over and above the full market rate of wages, a share in the net profits was given to the workmen. This system had been so successful in many establishments on the continent of Europe, particularly in France, that it appeared to him that it might have very valuable results in America, as it seemed especially adapted to a manu-

facturing population of a democratic character, such as had been described. He knew of one society, that at Peacedale, where it had been introduced, and should be glad to know if Mr. Pidgeon could give any further information regarding it.

Mr. J. S. JEANS said he was probably one of the few present who had studied and digested the report of the Massachusetts Labour Bureau; and he had also read carefully the still more excellent United States census reports. A few weeks ago he read a paper before the Statistical Society, in which he compared the rate of wages and conditions of labour in this country, on the continent of Europe, and in the United States, when the conclusions he arrived at were not quite identical with those set forth that evening. His figures were mainly based on the census reports, which covered a much wider area than that embraced in the report of the Labour Bureau, and the results brought out were briefly these; that in manufacturing and mechanical industries the average rate of wages for the year 1880 was £72 per person per annum, whereas in agriculture it was £52 per person employed, higher. Mr. Pidgeon had not given the actual rates of wages, but had only dealt with per-centages. A short time ago he examined the very volume of the Massachusetts Bureau of Labour Statistics from which Mr. Pidgeon's figures appeared to be taken, and he found that whereas, between 1860 and 1883, there had been a rise of about 35 per cent. in wages, the increase in the cost of living between the same dates had been higher still. And the most remarkable fact of all was that, according to the reports of the American Commissioners of Agriculture, the average rate of wages throughout the whole of the United States during the same period had fallen nearly 20 per cent. That seemed to him to be a more signal refutation of the wisdom of the American tariff system than was shown on the diagram. That the agricultural population, numbering nearly one-half of the wage-earning class, should submit to have their average cost of living, in regard to certain commodities, increased, as it had been, nearly 50 per cent., at the same time that their wages had been reduced, proved more eloquently than any other figures could do, that manufactures were flourishing at the expense of the agricultural classes. He gathered from the diagram that wages in England rose continuously up to 1877, but he believed that to be a mistake. He had a tolerably extensive acquaintance with two of the largest industries, employing certainly 800,000 persons out of a total of rather over 7,000,000 industrial wage earners, and he could say confidently that wages in this country reached their highest point at the end of 1873 and beginning of 1874, and from then they almost continuously declined until the present time. He regretted that Mr. Pidgeon had not given details covering a wider area, though Massachusetts was certainly the representative industrial State, and if the wages paid there were approximately the same as in New York and Pennsylvania, those three States would certainly include nearly 50 per cent. of the whole industrial population of the States.

Mr. HYDE CLARKE said it was unadvisable to mix up, in a discussion of this kind, the question of the remuneration of labour with the question of protection and free trade. However closely the two might appear to be united economically, as Mr. Pidgeon had said, these questions were not absolutely matters of figures. He had shown how much the welfare of the factory girls of Lowell, and of the operatives of the United States generally, depended on moral considerations, quite as much as on the immediate remuneration of labour, but we were all too apt to think that these questions were to be settled by figures, forgetting that we were dealing with human nature. People did not always attach themselves to a particular calling simply because it afforded more wages, as might be seen in the various trades in this country. He would also put in a word of caution against the use of averages, which were often misleading. Averages were not facts; they were useful to statisticians for certain purposes, but they often concealed the real facts. With regard to the question of protection and free trade in America, he remembered Mr. Mundella, on one occasion, making this remark at a meeting of the Statistical Society, after the usual strong arguments had been adduced in favour of free trade. He said he had just returned from the United States, and it appeared somewhat extraordinary to him that these arguments which appeared so clear and convincing had not the same effect upon men of equal ability and independence of mind there. He thought, therefore, that after all there must be something in the situation, or perhaps something in the individuality of persons considering the question, which was worthy of further inquiry. What Mr. Pidgeon had said with regard to the movement of the French Canadian population was of great importance, for the question of dealing with that population in Canada was one in which all Englishmen were deeply interested. It was always interesting to discuss questions which affected the whole mass of the population, and no distinction should be made between Englishmen born here or on the other side of the Atlantic. The descriptions given years ago by Miss Martineau and by Mr. Pidgeon now, all came home to them, though they referred to incidents on the other side of the ocean, for all that related to the English speaking population of 100 millions, would always have an interest for Englishmen.

Sir RAWSON RAWSON (President of the Statistical Society) said he would ask Mr. Pidgeon how the curves showing the rise and fall of wages on the diagram had been arrived at, and on what grounds he stated that the highest point of wages in England

was reached in 1876 or 1877, when Mr. Jeans, who had recently examined the subject very carefully, came to the conclusion that the drop began in the early part of 1874. In a week's time there would be a discussion in Prince's-hall of the highest importance, under the direction of the Committee of the Industrial Remuneration Trust, when these questions would be thoroughly considered. One of the chief points would be how the labouring classes would benefit by any such change in the distribution of the products of labour; a change by which, of course, all classes would be affected. It was not only a question of the amount of earnings, but also of expenditure; it was not what a man earned, but what he must spend out of that, which determined the amount left for comfort and improvement. For instance, he saw on the table that "groceries" absorbed 62 per cent., and he should like to know what that included; it might, possibly, in both countries be considerably reduced with advantage. The question of expenditure was more important, indeed, than that of wages, and the economy of the labourers' earnings was the most important of all. He hoped Mr. Sedley Taylor and others would aid in the discussion next week, and that much more light would be thrown upon this subject.

Mr. BARNETT remarked that the admirably clear way in which Mr. Pidgeon had marshalled his facts and figures, might well serve as a model to others who examined this question. He was greatly interested in the labour question, not only in England but in the States, and his own conclusions were singularly borne out in this paper; though, like Mr. Jeans, he did not agree with Mr. Pidgeon as to the time when wages in England reached their maximum; he considered it was in 1873 and the beginning of 1874, after which period they descended to the lowest level in 1879. It was a striking fact that wages in England and in the States always reached their highest and lowest point within a very short interval of each other. America always somewhat outran England in the race towards prosperity, and again in the downward direction, but there was seldom more than twelve months difference between them. There was, however, one omission in the paper to which he would call attention as being of some importance. Wages had been considered as an absolute quantity, but they were only the price of a commodity, and must be considered in relation to what they purchased. They must consider, therefore, not the wages merely, but the amount of energy put forth to earn them. Now, the average week's work in England was fifty-four hours, whereas in America it was sixty. There was, therefore, six hours' difference in favour of England, the American workman not having the Saturday half-holiday. The value of that six hours to the English workman was not simply the ordinary value of six hours, because if he were required to extend his week's work in the shape of overtime he received 25 per cent. additional, so that the six hours really represented the value of 4s., or 5s. per week in the Englishman's favour. What he had observed with respect to the wages movement in America and in this country was that there was a gradual downward tendency of the American rate to the English level; and as the diagram showed, after every period of depression in America, the wage-rate never went so high as it was before; whereas, after every period of depression in this country wages had always gone to a higher level. He was clear, therefore, that this movement would continue, until in a short time there would be very little difference in the absolute wage-rates of the two continents. Now was the time, therefore, when the American workman should insist on his hours of labour being reduced to those prevalent in this country, or else, under the competition which was bound to come in future, his wages would be brought down to the European level with more distressing conditions.

Mr. EDGCOME said one important point was the difference in the wages paid to agricultural labourers and those paid in the towns and cities. There must always be a great difference between rural and urban populations, and he should be glad if Mr. Pidgeon could give some idea of the difference in the cost of living in the agricultural communities in America and in urban districts. He must also enter his protest against the theory thrown out by one speaker that any fiscal system which benefited one portion of a community was calculated to inflict sufferings on another; and that the advantage to the manufacturing population was obtained at the expense of the agricultural, seeing that the latter found their chief market in the prosperity of the former. He could not see that the agricultural population in the United States had to pay a much higher price for the commodities they used in consequence of the tariff. Their food was naturally much cheaper; and their implements they bought at a less price than they could import them from Europe under a free trade system, as was shown by the fact that English manufacturers found the Americans very great competitors with them in colonial markets.

Mr. RHODES said the reader of the paper had not alluded to the incidence of taxation, considered not so much from the point of view of protection, as of revenue. In England, customs duties were employed as a means of raising revenue, not as a means of protection; but it would be found that the revenue raised in the United States by customs, cast taxation rather on the labouring classes, as a whole, than on those who were best able to bear it, viz., the propertied classes. He could not agree with what had been said by the last speaker. It seemed strange that in a country where protective duties prevailed, and where, of course, labour must be at a higher point, the products of labour should be so much cheaper than they

were in this country. With regard to the statement that Americans, in certain labour-saving machinery, were our successful competitors in other countries, he might remark that you could actually buy these kind of machines cheaper out of America than you could there. That arose in this way; the machines sold internally, in consequence of the protective duties, fetched so high a price, that the manufacturers could afford to take a low price in other parts of the world, in colloquial language, to keep their factories going. That was not a wholesome condition of things; and whatever might be said of the trade which the manufacturing classes carried on with the world at large, it was certain that the agricultural classes in America were under the most severe competition.

Mr. M. S. S. Dipnall had expected to find the subject treated more comprehensively, many important branches of industry being altogether omitted, such as mining, shipping, fishing, the army and navy, and locomotive industry. It seemed to him, therefore, that the investigation required to be carried further, in order to arrive at any satisfactory results.

The Chairman said he could not be expected, and indeed, in his position, it would be scarcely decorous, to express any opinion on the question which divided political parties at home; he had his own opinions, naturally, but must be pardoned for keeping them to himself. He had come there that evening owing to the interest excited in him by a little book of travels in the United States, written by Mr. Pidgeon, which was so interesting that he could not refuse when asked to come. It sometimes seemed to him that what Sir Henry Wotton said with regard to his own profession might be applied to modern travellers, that "they were persons sent abroad to lie for the good of their country." One would think, considering how much modern men of leisure were bored, that when they went abroad and found something unlike what they had been used to at home, they would thank God; but instead of that, they almost invariably complained. He remembered many years ago when he first visited England, he went to lunch at Dr. Johnson's old tavern, the "Mitre," and was much astonished at finding there were no napkins, having been used to them at home. He recollected also that French travellers in England, so lately as the beginning of this century, were astonished both at the absence of napkins and of silver forks, and could not imagine how the English contrived to eat peas with the two-pronged steel abomination which they found on the tables; but he was happy to say that they took this good naturedly, and merely mentioned it as a phenomenon. That was how such things should be taken—like variations in the weather. He had been particularly interested in Mr. Pidgeon's book, because it not only told him something new about his own country, but even about his own native State. One thing he thought he had noticed in the real American workman was the amount of brains which he mixed with his fingers, that had always struck him as compared with the workmen of other countries, and he remembered a story in Mr. Pidgeon's book which bore this out. Colonel Barrows, of Willimantic, holding up a piece of thread, said that thread would sustain more weight than any other thread of the same size in the world, because it was made by more intelligent workmen. Another point which interested him was this, Mr. Pidgeon said that American workmen had degenerated, but he should prefer to put it, that their energy had been turned into other directions. As the labour at Lowell received a large reinforcement, about 1832, by the fact that railways then began to be built in America, and a large foreign immigration began, so domestic service which had hitherto been performed by persons of American descent began to be performed by those of alien origin, and from that time the sons and daughters of farmers would no longer go out to service. He remembered perfectly when service was, to a certain extent, as Shakespeare said, hereditary; and he had in his mind a female servant, the third in descent, who had served three generations of another family; that family being that of his friend, Dr. Oliver Wendell Holmes. He had been much interested in the paper and the discussion, and particularly in the case of the French Canadians; and he could not help thinking that any degradation in the condition of these people must have arisen from too fierce competition of labour rather than from anything natural to the French *habitan* himself. Fifty years ago last summer, having passed his examination for entering college, he took his first independent journey, and went to Canada, which was then really a more foreign country than Europe. He had never seen anything in Europe so startlingly foreign to an American as Canada then was. You crossed an invisible border line, and went out of a country of Congregationalism and Protestantism into one where the Catholic Church had roots such as it hardly had in Europe, where the spires were covered with bright tin, looking like those which Don Quixote imagined he saw in his wanderings on the castles. He saw there the villages of the *habitans*, and was much charmed with them and with the people. They seemed a cleanly, simple, good kind of citizen; and he recollected being particularly struck with the brightness of the windows and the whiteness of the curtains, and, where he could see them, with the beauty of the floors; and he noticed that they always lived in stone houses. With regard to the point raised by Mr. Jeans as to the agricultural wages, it must be borne in mind that, since 1865, wages had been paid to a class of agricultural labourers to whom they had never been paid before—to a class where the wages were naturally at a much lower standard than they were in the Northern States—and this would of course lower the average in the census; so that perhaps, after

all, the figures in the Report of the Massachusetts Labour Bureau were fairer than Mr. Jeans supposed. Though he could not express any opinion of his own on the question of free trade or protection, he might say that the opinion of many far-sighted men in England was that the moment America adopted free trade, England would find in all the markets of the world the most dangerous and intelligent competitor she had ever met. If he were not mistaken, before 1860, the American mercantile marine was almost equivalent in tonnage to the English, and, he believed, it was the fact that the ships were better modelled and better manned than English ships, so that they were gradually taking possession of the whole carrying trade by canvass. The civil war came just at the time when the great change was going on from sails to steam, and from wood to iron; and he was expressing not his own opinion, but that of long-headed people on this side the water, when he said that owing to the navigation laws and the tariff, England got a start in the building of iron ships, which America had never been able to overtake. But it was also their opinion that, if America adopted free trade, England would find herself face to face with a very dangerous competition. He believed also, that many American fabrics were more honest than the English. Some twelve years ago, when in Venice, his wife requested him to purchase some calico, and he got some which was represented to be the best in the world, being English of make, and he, of course, thought it was all right; it was heavy and solid, and, to his unpractised eye, looked admirable; but the moment Mrs. Lowell examined it, by making a little notch, and ripping it, the whole room was choked with the dust that came out of it, and she said she had never met with such a thing at home. It had been reckoned by good statisticians that the inhabitants of the United States of English descent were almost entirely descended from immigrants who came over before 1660—before the the Restoration—and they had accordingly inherited that ingenuity which characterised the American workman. They had three, four, or five generations of self-helping ancestors, who were compelled to make up for the want of hands by some adaptation of mechanics; and this had been one of the great reasons why Americans had been so inventive, so ingenious, and so skilful in making the tools with which they performed their labour. He concluded by moving a hearty vote of thanks to Mr. Pidgeon for his interesting and valuable paper, and suggesting, with regard to the vexed question which had been raised, that most present would agree with Sir Roger de Coverley, that "a great deal could be said on both sides."

The vote of thanks having been carried unanimously,

Mr. PIDGEON, in reply to Mr. Sedley Taylor's question, said there had been very little done in the way of co-operative production in America. What had been done had been admirably summarised by the Rev. Heber Newton, in a paper published in the *Princeton Review*, about a year and a half ago, which he should be happy to send Mr. Taylor. He did not himself visit more than one profit-sharing establishment in the States, and that was at Narraganset, where Mr. Rowland Hazard had produced by this method the village of Peacedale, which more than justified the happy name it bore. He had not the pleasure of hearing Mr. Jeans' paper, but had seen a summary of it in *Engineering*, and was much interested in it. Mr. Lowell had already answered the question with regard to agricultural labour; up to recently there was no such thing in America, each man farming his own land. With regard to the diagram, he had been anxious to show that the tariff did not influence wages, and to be quite certain of avoiding the charge of giving a partial view, he had taken American figures. The American wages were taken from the report of the Massachusetts Labour Bureau, and so were the English from 1877 to 1880; up to 1880 they were taken from tables compiled by Mr. Lord, President of the Manchester Chamber of Commerce. After quoting from the American report to show the accuracy of his deductions, he repeated that he had adopted these figures to prevent any suspicion of having drawn the diagram in order to support a particular theory. Mr. Jeans asked why he had not taken a wider area; he should have liked to have taken the whole of America, but it would have required a week instead of an hour had he done so; and as Mr. Hyde Clarke had remarked, the question had a human side to it which was, in his opinion, more important than the statistical side. It would be out of place for him to argue the free trade question at length, he had simply brought forward the view generally taken by American operatives upon it. If the non-labouring population in America were now to change their opinion on this question, the working classes would say "No;" and the whole of that class would have to be converted before a free trade policy could be carried. Answering Mr. Barnett, he said that no doubt the comparison of wage-advantage would have been more exact if he could have put it in terms of hours instead of weeks, but it would have taken more time than he could afford to explain in what way the working week differed in the two countries. It was quite true that American goods could be bought cheaper here than in America, and it showed, what he had already stated, that the American manufacturer was dying for a wider market. He was connected with a commercial concern in London, which imported about £100,000 worth of American goods annually, and they were able to sell their goods in European markets against English competitors, simply because the American merchants were so extremely anxious to get a market, that the would supply them more cheaply than they could get them from any English maker. In conclusion, he had only cordially to thank Mr. Lowell for his kindness in taking the chair that evening, as well as for the flattering manner in which he had spoken of his work.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock :—

JANUARY 28.—"The Influence of Civilisation upon Eyesight." By R. BRUDENELL CARTER, F.R.C.S. R. J. MANN, M.D., F.R.C.S., will preside.

FEBRUARY 4.—"Education in Industrial Art." By CHARLES G. LELAND. Earl BROWNLOW will preside.

FEBRUARY 11.—"Report of the Royal Commission on Metropolitan Sewage." By Captain DOUGLAS GALTON, C.B., F.R.S.

FEBRUARY 18.—"Malt-making." By H. STOPES.

FEBRUARY 25.—"Past and Present Methods of Supplying Steam Boilers with Water." By W. D. SCOTT MONCRIEFF, M.Inst.C.E.

INDIAN SECTION.

Friday evenings at Eight o'clock.

JANUARY 23.—"The Agricultural Resources of India." By E. C. BUCK, Secretary of the Government of India in Revenue and Agricultural Department. Sir JAMES CAIRD, K.C.B., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings at Eight o'clock.

JANUARY 27.—"With the British Association to the Canadian North-West." By STEPHEN BOURNE. General Sir J. H. LEFROY, K.C.M.G., C.B., F.R.S., will preside.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings at Eight o'clock.

FEBRUARY 12.—"Production of Ammonia from the Nitrogen of Minerals." By GEORGE BEILBY.

The dates given above are subject to alteration.

CANTOR LECTURES.

Monday Evenings at Eight o'clock.

The Second Course will be on "Climate, and its relation to Health." By G. V. POORE, M.D

LECTURE III. Jan. 26.—The chief sources of Atmospheric Impurities, both Inorganic and Organic. Climatic Diseases and Climatic Health Resorts.

HOWARD LECTURES.

Thursday evenings at Eight o'clock :—

The fifth lecture of the Special Course delivered under the Howard Trust, on "The Conversion of Heat into Useful Work," by W. ANDERSON, M.Inst.C.E., will be delivered on January 29; and Lecture VI. on February 5.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 26...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. G. V. Poore, "Climate, and its Relation to Health." (Lecture III.)

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. H. H. Johnston, "Expedition to Mount Kilimanjaro and the Snow Mountains of Eastern Africa."

Actuaries, The Quadrangle, King's College, W.C., 7 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m.

TUESDAY, JAN. 27...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Mr. Stephen Bourne, "With the British Association to the Canadian North-West."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. H. N. Moseley, "Colonial Animals, their Structure and Life Histories." (Lecture III.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Adjourned Discussion on Mr. Hamilton-Smythe's paper, "A Comparison of British and Metric Measures for Engineering Purposes." 2. Mr. David Salmond Smart, "The Design and Coustruction of Steam Boilers."

Anthropological, 4, St. Martin's-place, W.C., 8 p.m. Annual meeting.

WEDNESDAY, JAN. 28...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. R. Brudenell Carter, "The Influence of Civilisation upon Eyesight."

Geological, Burlington-house, W., 8 p.m.

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. R. Nelson Boyd, "The Petroleum Fields of Europe."

THURSDAY, JAN. 29...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Howard Lectures.) Mr. W. Anderson, "The Conversion of Heat into Useful Work." (Lecture V.)

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. S. B. J. Skertchley, "The Geology of the London Streets."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. Brinley Richards, "Welsh Music, Ancient and Modern." With Illustrations.

Royal Institution, Albemarle-street, W., 3 p.m. Professor Dewar, "The New Chemistry." (Lecture III.)

Mechanical Engineers, 25, Great George-street, S.W., 7½ p.m. Annual General Meeting. Reading of Papers and Discussions.

FRIDAY, JAN. 30...Mechanical Enginers, 25, Great George-street, S.W., 7½ p.m. Reading of Papers and Discussions.

United Service Inst., Whitehall-yard, 3 p.m. Major G. Mackinlay, "Mild Steel applied to Naval and Military Purposes."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Prof. E. Pauer, "A Short Review of the Work of Living Composers for the Pianoforte." (With musical illustrations.)

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. F. W. Stokes, "The Iron Bridges on the Hull, Barnsley, and West-Riding Junction Railway."

Browning, University College, W.C., 8 p.m. Mr. A. W. Symons, "Is Browning Dramatic?"

SATURDAY, JAN. 31...Royal Institution, Albemarle-street W., 3 p.m. Dr. Waldstein, "Greek Sculpture from Pheidias to the Roman Era." (Lecture III.)

Journal of the Society of Arts.

No. 1,680. Vol. XXXIII.

FRIDAY, JANUARY 30, 1885.

All communications for the Society should be addressed to Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The third and final lecture of the course on "Climate and its Relation to Health," was delivered on Monday evening, 26th inst. Dr. Poore began by again referring to Miquel's experiments, which seemed to show that the number of microbes in the air was always proportionate to the density of population. In hospital wards which were occupied the whole of the twenty-four hours, and where the aggregation of productive foci of microbes reached a maximum, the number was necessarily large. Many diseases which were probably caused by floating matter in the air were then passed in review. Hay fever had been proved by Mr. Blackley to be caused (at least in his own case) by pollen grains carried by the atmosphere. A notable instance of disease caused by fungoid spores was found in the potato disease. The disease was due to a fungus preying upon the leaves and other tissues of the potato plant, and there was scarcely room for doubt that the spores of this fungus might be carried by the air, and infect large districts. Epidemic influenza, which has not appeared in this country since 1847, was certainly an aërial poison, and for suddenness of onset and extent of its ravages, it was comparable to the potato disease. There was scarcely room to doubt also (in the face of recent evidence) that the infective particles which are the cause of small-pox, may be carried some hundreds of thousands of feet at least. The commonest of all diseases, consumption, or phthisis, had been lately proved to be due to a bacillus, and, therefore, for the future, must be looked upon as an infective disorder, and not a local one. Many of the facts which had long been recognised and understood with regard to phthisis gave much support to the theory of its infective nature, and chief among these was the undoubted fact that mortality from phthisis was directly proportionate to overcrowding Soil was a climatic factor which had considerable influence on health, especially when the combination of warmth, moisture, and decaying organic matter gave rise to malaria. After alluding to the peculiarities of mountain climates, Dr. Poore concluded by saying that he had endeavoured in these lectures to show that many diseases which we were apt to attribute to climate were in reality due to our own ignorance. A knowledge of the laws of sanitation, and a strict application of those laws, has greatly improved the health of the British soldier both on home and foreign stations, and a reference to the health returns of the army was the best proof of what he had asserted with regard to climate.

The Chairman (Mr. B. F. Cobb) proposed a vote of thanks to the lecturer for the valuable and interesting course he had delivered, which was carried unanimously.

The lectures will be printed in the *Journal* during the summer recess.

PRACTICAL EXAMINATION IN VOCAL AND INSTRUMENTAL MUSIC.

The next Examination in London will be held by Mr. W. A Barrett, Mus.Bac. (Oxon.), at the House of the Society of Arts, 18, John-street, Adelphi, W.C., during the week commencing 8th June, 1885.

Full particulars can be obtained on application to the Secretary.

Proceedings of the Society.

INDIAN SECTION.

Friday, January 23, 1885; Sir James Caird, K.C.B., F.R.S., in the chair.

The paper read was—

THE AGRICULTURAL RESOURCES OF INDIA.

By E. C. Buck.

I could almost have wished that the honour which has been conferred on me, in being invited to address the Society to-night, had

been postponed till next year, because I should then be able to demonstrate what I have to say by the charts illustrative of the industrial and agricultural resources of the Empire, which the Indian Survey Department is engaged in preparing for the London Exhibition of 1886, by the express desire of H.R.H. the Prince of Wales.

I am afraid, too, that you may be disappointed when I tell you that I have practically no figures or statistics to give you. I have a dozen good reasons for withholding them, but the twelfth and last that there are none is, perhaps, the best. None, I mean, for the whole of India, and there is no time, even if it were not unsatisfactory to do so, to go into details with respect to selected provinces. The map to which I direct your attention shows the areas for which statistics can be made available and those from which none are forthcoming. The latter area occupies, unfortunately, very much the larger area of the two. The fact is, that it has only been in provinces and tracts in which the land revenue is periodically assessed and modified, that statistical records have hitherto been constructed, and they have been framed once only in every twenty or thirty years by our settlement officers, *i.e.*, the officers entrusted with the duty of assessing the land revenue, to whom we owe the greater part of the knowledge which we possess of the agricultural life of the people of India. One of the chief reforms, however, which has been grafted by Lord Ripon on the recommendations of the Famine Commissioners—who, above all things, urged the careful collation of agricultural facts and figures—has been the substitution of permanent settlement departments, under the name of agricultural departments, for temporary or periodical settlement establishments. I do not mean by this term departments to make permanent settlements never to be altered, like that of Bengal, or one which is to perpetually assess and harass the people with new assessments. I only mean departments which are to maintain a perpetual or continuous record, which will make available every year the information which the settlement officials collected only once in twenty or thirty years. In introducing this measure, the Government of India only confirmed the wishes and actions of the Governments of the Presidencies and Provinces, Sir John Strachey having led off in the North - West Provinces, and much having been done in Bombay, Madras, the Panjab, and Burma in the same direction. But it was the advice of the Famine Commissioners—the value of whose mission to India I shall take a further opportunity of acknowledging—that led more immediately to a systematic accumulation of agricultural facts and figures being undertaken. Next year, as the first fruits of this reform, you will receive a deluge of statistical information; but I must ask you to wait for twelve months before you undergo your statistical shower-baths.

I can also promise then a satisfactory answer to a question addressed the other day to the Secretary of this Society by an eminent Indian official now in Parliament, and which I have often heard made by others—Whether any Government Report or Blue-book had yet been published, in which statistical and other information about the agricultural products of India could be obtained. There is no such publication at present, but as a guarantee that there will be, I am able to-night to offer for inspection the first of a series of volumes, which will be completed in a twelvemonth, giving a complete account of all the commercial and economic products of India. This will, it is hoped, be quinquennially re-published. I am sure that Sir James Caird will be glad to know that the accomplishment of this commercial and economic survey is due, in a great measure, to the counsel and advice of the Famine Commissioners.

But I must leave off talking of the information which I am not prepared to give to-night, and turn to what I can supply. After what I have said, you must be prepared to pardon me if I confine myself to remarks of a general character, which will, however, be perhaps accepted as preliminary to the more detailed information promised in 1886. I propose to say, then, a few words about the climate and natural advantages of India; the great variety of its agricultural systems and produce in different parts of it; and, finally, to indicate in what directions it seems likely that its productive powers can be enhanced, and what measures are being taken by the Government to secure that result. I am, for one, convinced that, under British rule, the position of the agricultural population, and the producing capacity of the country are, and will continue to be, materially improved; and I am not afraid to assert that the resources of India are capable of a further development which it is impossible, as yet, to measure.

First, it is necessary to give some approximate idea of the size and extent of the Indian

Empire. I candidly admit that upon no one do I find it more difficult to impress that idea than on myself. I find it difficult when in India, but here in England still more so. India then dwindles down into a little triangular spot of land on the P. and O. Company's route map, and seems to present itself through the wrong end of a telescope. I will, however, with your permission, try to turn the telescope the other way. I will not attack your imagination by statistics of square mileage, because, judging by their effect on myself, I do not believe in figures as conveying a just idea of size. I have more faith in a comparison with some familiar object, and in casting about for one in the present case, I can hit for the moment on no better one than Egypt—Egypt proper, I mean, exclusive, of course, of the deserts and the Soudan. The public has its attention now drawn to that country, is accustomed to see maps of it, and has probably formed a fairly correct idea of its extent. It has, moreover, the advantage of being, in its agricultural character and population, more like parts of India than any other country west of the Suez Canal. Well, then, taking Egypt proper as the unit of measure, I will first compare it with the province I know best, viz., the North-West Provinces, exclusive of Oudh. This Indian province is, for administrative purposes, marked off into five large and two small so-called divisions, each being administered by an official called a Commissioner, who serves under one Lieut.-Governor. Now, assuming the population of Egypt to be 5,500,000, and its cultivated area to be 5,500,000 of acres, which are, approximately, the figures given in Baron de Malortie's "Egypt," as those of the last year of Ismail Pacha's reign, we find that in cultivated area four out of the five large divisions of the North-West Provinces are each of them equivalent to about four-fifths of the Egypt unit, while the fifth division is an Egypt and a quarter. The statistics of population bring out similar results. Altogether, in cultivated area and population, the North-West Provinces are equivalent to about five Egypts. The little province of Oudh, which is held like a ball in a cup by the North-West Provinces, is as large as an Egypt and a half. Bengal would absorb no less than ten Egypts; and the Panjab three and a-half more; Bombay, with Sind, about the same; Madras, about eight Egypts; the Central Provinces in population less than two, but in cultivated area more than four, with a possible, if not probable, extension to eight Egypts. British Burma gives one Egypt, with a possible extension to several more. Assam, of which an Egypt and a-half is cultivated now, can be, it is believed, expanded into at least four. Berar, less than an Egypt in population, exceeds it in cultivated area. So far the British provinces. I will not venture into the Native States. Of the large number of Egypts which they would absorb, you can, perhaps, form some judgment, by comparing the space which they occupy on the map with that taken up by British provinces.

I now pass to the climate of India, and in doing so, I will ask leave to turn round that telescope for a few minutes the other way again, and to let India dwindle down once more into an insignificant looking spit of land jutting out from the enormous continent of Asia. Why should that triangular shred, hanging from the vast steppes of Central Asia, possess such infinitely greater value than the immeasurably more extensive trans-Himalayan regions? The answer can be given in one word, "rain." It is needless to say that great agricultural wealth can be produced only in alluvial land watered by showers or rain-fed floods, and without rain there can be neither the alluvial land, nor the showers and the floods. It would be interesting if a new map of the world were made, from which all land without rain or rain floods should be entirely excluded. The comparative value of countries would become far less obscure. And I have two reasons for apology in dwelling upon these simple physical facts; the one to give as much prominence as I can to the agricultural superiority of India over the vastly more extensive regions which surround it on the North; the other to indicate its agricultural inferiority in some, though not in all, respects to smaller, but more favoured, tracts in the equatorial seas, and to which I shall have to revert presently as having an intimate connection with the agricultural prosperity of India. China is, perhaps, the only country in the East which ranks on the same level as India.

But although the monsoons of India confer upon it its agricultural rank amongst other countries, yet, within India itself, they vary immensely, and create enormous varieties of climate in combination with two other varying factors, (1) the temperature due to latitude, and (2) dryness due to distance from the seaboard, or to the scantiness of underlying water; the consequence is, that there is no crop in the world which India cannot produce. This is a great advantage. Now, defining a monsoon as a

fall of rain which occurs more or less continuously during a tolerably well-defined period of the year, there are three monsoons in India, not one only. Dividing the year into four quarters, we have, very roughly speaking, in the third quarter the south-west monsoon—the monsoon *par excellence*—extending, if it behaves properly, over three-fourths of the Indian continent; in the fourth quarter the south-east monsoon, extending over the eastern half of the southern peninsula; in the first quarter of the year the north-west monsoon (believed to be a posthumous child of the preceding south-wester), which stretches over the Panjab and some other parts of Northern India, and has much to do with the wheat harvest; in the second quarter only there is, with the exception of showers in some parts of Bengal, no indication of a monsoon. Now, it is the combined force of these three monsoons, mechanically assisted by the mountain ranges, that provide the agricultural resources of India, and raise it to an importance which the barren wastes of the huge continent to which it hangs cannot reach. But it is not only in pouring showers and moisture on the crops of each year that the monsoons create the agricultural resources of India; they also wash down, and have for ages washed down, in rivers and floods, the fertile soil on which their crops are grown. They also fill vast underground reservoirs with perpetual seas of fresh water. They supply the mountains with their snows and springs. River after river debouches from the grand Himalayan range, to be lifted one after another by the toil and talent of English engineers, and spread over the thirsty plains; and not only so, but, though it seems somewhat unfair, even the rain waters which descend to the trans-Himalayan regions refuse to enrich Central Asia, and beating like trapped birds against the bars of a cage, press along the outer base of the mountains, till they reach a friendly opening, through which they turn with a sharp and eager bend into the plains of India. Thus the Indus and Brahmaputra, the great rivers of the west and the east, break through into the Panjab and Bengal. Lying dormant, too, in the annually renewed reservoirs of mountain-stored water, is an enormously powerful mechanical force which will, some day, be enslaved and controlled by the patient perseverance of our engineers, and will do much to make up for the absence of coal in the northern continent. I now wish to lay very great stress indeed upon one point. Although the monsoons confer all this agricultural wealth, the uncertain character of the rain, in the greater part of India, is so excessive, that the agricultural out-turn, so far as it depends on the rainfall *of the year*, oscillates violently. English farmers did not, perhaps, know at one time what a violent oscillation of produce meant, and always expected to get twenty-eight to thirty-two bushels of corn an acre, whatever the season might be. They have had more experience lately, but they would be taken aback, perhaps, if they were asked to cultivate farms in which it was a mere chance whether the out-turn would be nothing, or twenty bushels an acre. How to overcome this oscillation, or to mitigate its effects, is the great problem which has to be solved, and it is, I am glad to say, being vigorously attacked, and, to some extent, solved in India.

Unfortunately it is in the areas of uncertain rainfall, which are the battlefields where a continual fight between death-dealing desiccation and life-bestowing moisture is carried on, that the largest populations are often found, and it is only by bringing to their aid every means of assistance (not irrigation alone) to enable them to overcome or mitigate the effects of desiccation, that the agricultural out-turn of the Empire can be most materially increased. Before indicating these means, I will try to give some little idea of the area of uncertain rainfall. I have before me a map showing the average rainfall for the past thirty years, in different shades of blue. I will divide them into two sections, light blues and dark blues. The dark blues always, or almost always, have enough rain to produce a crop sufficient for the maintenance of the cultivator, and the payment of his rent. The light blues have, more or less often, too little rain to produce a sufficient crop. Most prominent among the dark blues are Eastern Bengal, Assam, Burma, and the Central Provinces, and a strip in Madras, west of the Ghâts. Most prominent among the light blues is an enormous belt, which I would venture to call the shrinkage area of the south-west monsoon, which stretches like a sash from the Panjab through the North-West Provinces and Rajputana, and then tying itself up in a knot on the south-west edge of the Central Provinces, drops in a wide and ragged band through the Deccan, Mysore, and Western Madras. It would, as you may see, absorb many Egypts. When the monsoon is somewhat under the mark, it is in this area that its shrinking brings the produce below par—

often below the amount which is sufficient for the food of the year. There are many other areas in which the shrinkage of other monsoons, or of the south-west monsoon itself, causes similar results, but this belt is the most important. The sash part of it represents that portion which is not properly reached by the sweep of a weak monsoon. The hanging band represents what I may call the rain shadow of the Western Ghâts, and it is full of ragged holes, in other words mottled with dark and light blues because the mountain wall is of an irregular shape, and in some places lets the rain-clouds through much more freely than in others. When the monsoon is light, the light blue holes suffer most.

I must now say a few words about the agricultural population. I have no time to describe the various races which comprise it, or their different agricultural systems; I must confine myself to the question whether they are, as a rule, in a position to make the most of their natural advantages, and must treat the subject in the briefest manner.

Let me begin, however, by asserting that, owing partly to historical causes, and partly to the fearful struggle that has to be carried on with nature in many parts of India, the Indian cultivators have, as a rule, developed into the most patient, hard-working, and, in many cases, skilful agriculturists that can be found on the face of the earth. Inured to privation, accustomed to maintaining life on short meals, and with scanty clothing, they give their labour for the smallest return it is possible to conceive. The consequence is that, broadly speaking, the agriculture of the country is carried on by a vast human machine—a machine of flesh and blood—which is cheaper in its working than it is possible for any machine of steam and iron to be. I have just met a Public Works official who went from India to America to look at the agricultural machines in that country. Nothing, he said, struck him more than the way in which machines diminished in size and frequency as he passed from a region of high wages to a region of low wages. In India, we come down to a region where the wage-level is so low that the multiplied power of human muscles, or the multiplied power of very weak cattle, supersedes all but machinery of the very lowest order. Wages are rising, and will continue, with civilising influences, to rise still more; but until they do, the question of increasing the products of the country by the application of machinery must be considered a secondary one. The first and primary question is, how far it may be possible for the Government to increase the effective working power of the two flesh and blood machines—the men and their cattle—and thus fulfil a duty which a feeling of humanity, as well as a desire to develop agricultural wealth, impose upon it. The system of agriculture is, as you know, eminently one of *petite culture.* I shall be exaggerating very little if I say that the country is split up into so many millions of five-acre farms. The holders of these farms are small tenants, paying rent, over a large part of India, direct to the State, and, over a still larger part, to a landlord, or a landlord intermediate between them and the State. As a rule, the cultivator will do anything that is necessary within the boundaries of his own five acres; it is a delicate matter to meddle with him there. But outside his five acres he can do nothing; and as (with due regard to certain bright exceptions) the intermediate proprietor avoids doing anything, it devolves upon the Government to take whatever measures may be possible and expedient—(1) to prevent the deterioration of the working power of the agricultural machine, and (2) to improve its working power. Five years ago, England sent a message to India that the people must not be allowed to die of starvation. But Sir James Caird and General Strachey, who bore that message, found that much more was necessary than to provide the starving people with food when famine was on them. It was necessary, they found, to secure to them a normal condition of strength and health; and the consequence was that the exhaustive report, written when the labours of the Famine Commissioners were concluded, by their able secretary (Mr. C. A. Elliott), suggested administrative reforms of all kinds, which, at first sight, had little to do with the question of famine, but which, on examination, were found to have very much to do with it indeed. For the whole country being built up, as it were, of those five-acre bricks, it is found that all administrative problems, however intricate, can be resolved into factors in which the five-acre unit, and the prosperity of the five-acre holder, is the most important one of all.

The net result of the Famine Commissioners' mission was a further message to India from her Majesty's Secretary of State, inviting closer inquiry into vital and economic facts, and the adoption of measures tending to increase the produce of the country as well as to cope with famine. The words in which Lord Ripon

gave this message to the country, show that his Lordship considered that to strengthen and improve the condition of the cultivators was the leading measure necessary for the increase of agricultural wealth :—

"It is necessary to point out that the agricultural inquiry should not be confined to the mere collection or collation of statistics in the ordinary acceptation of the term. An examination of the portion of the Famine Commissioners' Report which deals with agricultural inquiry will show that, in recommending with reiterated force an intelligent system of investigation, their final object is to urge through its means, and as a practical outcome of its results, the policy of maintaining agricultural operations at the highest attainable standard of efficiency. The Government of India fully accepts this definition of a most important aim of agricultural inquiry. The maintenance of agricultural operations implies the sustenance of agricultural labour, and the complete provision of agricultural requirements; and in India this means that cultivators, their families, and cattle must be properly fed, and their need for labour, irrigating machinery, and agricultural implements adequately met. Now, insufficiency of food, as well as the deterioration or lack of mechanical appliances, must diminish the effectiveness of labour, and thereby reduce the produce of the country. If, therefore, through rack-renting or any unsuitable system of collecting rent, if from inability to obtain capital on reasonable terms, or if from accidents of season and other causes, the amount of produce becomes less than sufficient to provide the sustenance and appliances required by labour and land, it becomes the imperative duty of Government to ascertain whether any legitimate means can be provided to check the degradation of agriculture which must otherwise ensue. On the other hand, if by any means the efficiency of agricultural operations can be increased, a larger amount of produce will be available, both for the support of labour and the provision of mechanical requirements, and also for the rent fund from which the land revenue of the country is derived."

It is in the proper application of these principles that the future increase in the production of the country will be effected, and it is in these terrible battle-fields, of which I have spoken, that their application is chiefly needed, in order to enable the cultivator to make a successful stand against desiccation and uncertainty of out-turn. I will indicate briefly the directions in which the State, or landlord-in-chief, is taking measures for the maintenance of the full working power, as well as for the increased efficiency of the great muscular machine. They are these:—The promotion of railways; of canal irrigation, and of well irrigation; the improvement of the revenue and rent systems; the reclamation of waste lands, with the establishment of fuel and fodder reserves; the introduction of agricultural improvements; and, finally, emigration.

Railways, with few exceptions, tend to ameliorate the condition of the cultivator mainly in two ways. Firstly, they ensure him a better average price for his produce when he has a surplus for export; secondly, they bring him food at a cheaper price when he has insufficient for subsistence. On the one hand, his average receipts are greater, and on the other, his average cost of living less. For assuming, as we may, that the bulk of the agricultural population pay no cash for food, except when their own crops are insufficient for sustenance, the change in price caused by the railway is all in his favour. But there are two questions which have, within the last year or two, cropped up in connection with the effect of railways on food, with respect to which I should like to say a word or two. One is the position of a remote tract, in which corn is said to be raised at a very small cost, and which is assumed to be worth tapping because the price is low. But is it not the case that the price is simply low because the corn cannot get away to a market, and that the cost of it is small because the wages are calculated in terms of the corn which, as matters stand, has little or no value? But bring a railway to a tract like that, and the price of the exportable surplus will at once rise to the market value, and with it the price of labour, by the conversion of the wages into cash at the new money rate. Is not then the real benefit of the new railway to give to the cultivator of that tract a more substantial return for his surplus, and supply that surplus at a cheaper rate than it would otherwise be carried to a distant point on the railway where there is no surplus, or to a port? The other question is this. A fear has been expressed—I am not sure that an assertion has not been made—that railways, by facilitating the export of wheat, injure the country, because they deprive it of a part of its food supply, and that the population of India being already underfed, should not be allowed to lose a single pound of food. This argument, carried to its logical conclusion, would render it a duty to obstruct the export of all agricultural non-food commodities, such as cotton and oil seeds, which could, of course, all be replaced by food crops. But what I specially wish to say is this, that it seems wrong to argue at all about India as a whole. What

it would appear right to do is to analyse the wheat exporting tracts one by one, and ascertain whether the wheat has deprived the agricultural population of any one tract of any portion of its food supply. Such an analysis is being made, and so far as it goes, it shows that the export of wheat has not deprived the agricultural population of the exporting province of a single pound of food, but has, on the other hand, enriched them by an increase of about 50 per cent. in the value of the produce exported.

On the whole, the expenditure of capital on railways, does, by providing the cultivators of precarious tracts with cheaper food when their harvests are insufficient, afford a quicker benefit to a greater number than irrigation or any other measure Government can undertake, and rightly heads the list.

The next means of aiding the cultivator in his fight against the desiccation caused by the caprices of the monsoon of the year, is irrigation by canals and wells, *i.e.*, by the utilisation of water stored up by monsoons *of previous seasons* in the mountain ranges, and in underground seas. A very great deal has yet to be done to make these stores further available, notwithstanding the magnificent labours of our engineers. When the Famine Report was written, out of about 200,000,000 acres of cultivated land in British India, only 8,000,000 acres were watered by irrigation works, and 12,000,000 acres by wells. All I can say is, that every nerve is being strained by our Public Works Department to develop canal irrigation; and next year we shall be able to show you maps of what has been done, and can still be done.

Many people have an idea that canal irrigation injures land. The idea is a dangerous one, because it contains half the truth. Water freely applied stimulates production so enormously, that the soil becomes temporarily exhausted, and the produce is, sometimes for a series of years, less than it was before in an average year. But the certainty of a harvest gradually attracts a population. The manure supply and cattle increase, and the ultimate produce becomes much greater than at first. I believe the best safeguard against the intermediate exhaustion of which I have spoken, is to charge a full price for canal water, and thus prevent its wasteful use. Be this as it may, it is impossible to over-estimate the utility of canals in securing certainty of production in every tract in Northern India, where the underground freshwater sea is too far from the surface to be cheaply tapped.

The present policy is to confine, as far as possible, the expenditure of capital to such tracts. For where the water is near enough to the surface, say on the right side of 50 feet, the agriculturists can build themselves wells, and, as a rule, they can build them more cheaply than Government, and only want advances and freedom from excessive taxation of the water as an encouragement to construct them. This encouragement is now being given; and after a long series of experiments, conducted by the officer of the Public Works Department, before mentioned, and whom I now see here to-night (Mr. Wilson), it seems proved that the best direction in which Government can offer positive aid is in employing boring tools to ascertain, by a cheap trial, the character of soils and water in doubtful tracts, *i.e.*, in tracts (very extensive and numerous) in which the cultivator is afraid to undergo the costly experiment of sinking a well through unknown strata, without being sure of results.

On the whole, I believe that the irrigation of India may be increased ten-fold over the area of uncertain rainfall, and that the produce may be doubled on the irrigated area.

The next means of increasing the produce is by the reclamation of waste land, and the establishment of fuel and fodder reserves. I put the two together, because it is believed that in the area of precarious rainfall it is wiser to utilise many of the waste tracts by converting them into grazing lands, than to grow crops on them. The Famine Commissioners estimated that there were more than 100,000,000 of acres of cultivable waste in the British Provinces, of which, perhaps, one-half are in the precarious area. But there are in addition several millions of acres now classed as unculturable, much of which it may also be possible to convert into grazing land. A word or two now about the cattle which form so important a part of the machine of "flesh and blood," of which I have talked. Sir James Caird will no doubt permit me to say that, in comparing the agricultural condition of Egypt and India, he noticed the much larger proportion of the cultivated land in Egypt which is annually employed in the growth of fodder for cattle, and the consequent maintenance of a powerful working stock, capable of deeply stirring the land, and supplying good manure. "There is nothing of the kind," he wrote, "in India. The cattle in most parts are half starved, and their manure is used as fuel." This is true unless we except some few fully irrigated tracts.

One of the saddest sights in India as we travel for hundred of miles by rail, through that belt of monsoon shrinkage in the second quarter of rainless months, is to see the cattle standing without food, and almost without shade, exposed to a scorching heat, which imagination fails to realise, in the midst of arid plains bare of all sustenance. But when the period of desiccation is prolonged beyond its normal limits to the third quarter, the sufferings of the poor beasts are awful. Meanwhile, the strength of the agricultural machine on which the operations of the forthcoming season depends is, of course, frightfully diminished by every day's delay. Sometimes the delay is, as in 1877, so great that the cattle die in thousands, and even millions. In one district, for instance, 250,000 disappeared out of 500,000. Unfortunately neither railways, nor (as a rule) irrigation bring food for cattle. Both railways and water are wanted to sustain the human part of the machine. The only remedy is, firstly, to establish plantations of fodder trees, the roots of which draw on the underground fresh water sea for their moisture, and protected by which grass and fodder bushes will grow; and secondly, to secure the grazing land from destruction by goats, which are more than anything else accountable for the disappearance of natural cattle food from the country. This measure will not only sustain the cattle power, but by increasing manure, and by supplying fuel to take the place of manure, will add to the richness of the area already cultivated, which will then support a larger agricultural population, and with this advantage, that they will secure a far more certain harvest by improving their present fields, than by raising precarious crops on the now waste lands. The Madras Government has already adopted the above policy, which the Government of India and other local Governments are also, in the face of many difficulties, attempting with the aid of the Forest Department, to introduce elsewhere.

I wish I had time to describe the experiments being made by Mr. Wilson, among others, for the reclamation of the alkali-poisoned plains which cover several thousand miles of the belt of monsoon shrinkage in Northern India. The map I have here will show you how they are interspersed with the best and most thickly populated land—land which carries often 1,000 to 1,200 on the cultivated square mile. There are great hopes of converting some of these alkali wastes into good pasturage lands, for when once the alkali is mastered, it becomes a useful manure instead of a hurtful poison.

Another means of strengthening the cultivators is by judicious improvement of the revenue and rent systems. I will not attempt to go into this subject, especially as it was so ably dealt with by Mr. Pedder in this room a few months ago. I will only say that one of the chief objects of any amendments which may have been proposed of late years, has been to increase the efficiency of the five-acre holder, for the ultimate benefit of all who have any interest in the land.

I now pass to a subject which has not always received the attention which I think it merits, viz., emigration.

As there is beyond England a "Greater Britain," so there is beyond India a "Greater India." I do not mean a greater India for the Empire, but a greater India for the five-acre holders, and the surplus members of their families. To whatever nation the proprietors may belong, the equatorial sea-girt lands offer an unlimited labour market. I have already indicated their superiority to India in the absence of any struggle with desiccation. The fact is that they have a moist, equable, not unpleasant and extremely fertilising climate all the year ronnd. In Java, for instance, there is a little rain every day. In an interview which I was permitted to have with the Governor-General of the Dutch Indies, his first words were, "We in India do not suffer from famines as you do in British India." (India to the Dutch is not British but Dutch India.) So it is throughout the equatorial sea-washed lands, inclusive of Northern Australia, and parts of Africa, and South America. I have not figures at hand to show the magnitude of this labour field, but you may gain some idea of its size as compared with India, when I mention that if a line be drawn from Calcutta to Bombay, the whole of India below that line will be just equal to Borneo. But if we compare culturable land with culturable land, it is probable that Borneo is double the size. Nature, however, in bestowing rich vegetable wealth on these regions, has accompanied her gift with the drawback of a lazy population, lazy because the climate is enervating, and because nature pours food into their lap. They are not braced up by the hard fight with nature which produces the patient, sinewy, and hardworking Indian coolie. So it happens, therefore, that the capitalists in the Fiji Islands, from which the Australians in vain attempted to obtain sufficient labour for their

tropical lands, have now themselves procured labour from India. Is not this a significant fact? So again, the Governor of the Straits Settlements, to which colony I was deputed on a mission connected with emigration, sent me the other day up to the top of the mountain range between Siam and the protected States of the Malay Peninsula, in order that I might see the coffee berries rotting on the bushes, for want of Indian labourers to pluck them. I hope that arrangements are now such that he can get the labourers he wants, and there will henceforth be the same ebb and flow of Indian labour to the Malay peninsula that there is to Burma and Ceylon, to which countries thousands of agriculturists migrate —like swallows—every year. Rather, perhaps, I may compare them to a line of ants, which go backwards and forwards to rich heaps of grain, from which they bring back a welcome store to their own homes. This is the point. By his labour abroad the Indian agriculturist accumulates a capital to be expended on the five-acre farm at home, and that is, above all things, what is wanted, not an increase in the number of five-acre farms, but expenditure of more capital on those existing. It is often said that, while there is waste land in India, why send labour abroad? I have given one reason, but there are two other strong reasons. One is that the Indian labourer cannot settle without a capitalist protector, and that there are few capitalists ready to risk money in new land in India; they make more and risk less by lending money on the cultivated area—whereas in the "Greater India" every capitalist is (like Sir F. Weld's coffee planters) ready to give (at once) double wages. The other reason is that if we neglect any opportunity of letting the labour market be supplied by Indian cultivators, it will be occupied by Chinese, the only other labourers of the East to whom a hard struggle with nature in a dry climate has given energy and patience. In 1883 100,000 Chinese went to British Malay possessions against 4,000 Indians.

My last subject is the positive improvement of agriculture, by new machines and new methods. Here, I think, we must trust chiefly to our educated native farmers, and to English planters, which latter class has done most of what has been done to improve Indian agriculture, if we except the valuable work done by Government in the introduction of tea and cinchona. It is the duty of the State to collect and disseminate information, and to try experiments of all kinds, and this is being done. But until the strength of the cattle is permanently enhanced, it is useless to advocate the use of much more effective field machinery. I believe, however, that the time may come when the riches still stored in the unused soil below the surface, now scratched by the native plough, will add materially to the agricultural wealth of the country, and at the same time protect the vegetation from the withering effects of desiccation.

As a proof of all that I have now said, I may mention that the only machine which has met with unqualified success in superseding a machine of the country, is a small portable sugar-mill with iron rollers, that can be carried by two men, and worked by one weak bullock, which is replacing the wood or stone pestle and mortar in which natives have hitherto pounded their canes. It is now sold by thousands. But the machine was not brought to its present state of perfection without years of patient trial and experiment, although its inventors, Messrs. Mylne and Thompson, planters of Bengal, were thoroughly conversant with the local agriculture. This fact indicates, firstly, that the improvement of native machinery can only be worked out by experts on the spot; secondly, that the natives will not, when they are convinced that a machine is profitable refuse to take it. These conclusions justify the continuance of steady perseverance in experiments by local experts, but does not encourage the transmission from Europe and America to India of expensive machines, which have not been modified by competent experts so as suit the conditions of the country. It is a standing joke in connection with agricultural experiments, that a native will not use an English plough because he cannot reach the bullock's tail to twist it, which is his only method of urging his beast to further exertion. There is a grain of truth in this chaff. But the real success which has been reached in the case of the sugar-mill, and the incipient, and I hope no less real, success which has attended the experiments conducted with much skill and perseverance at the Madras Government Farm, or by planters in Bengal, and elsewhere, justifies, as I have said, continued efforts. My own belief is, as I have already indicated, that there is at present not much chance for machines that merely save labour (except in Burma, where labour is costly); there may be some hope for machines that do work which no labour, *i.e.*, muscular power, can effect. But it is in very slight

and gradual improvements in simple draught machines and hand implements that most progress can, I think, be made. Here is one of the latter class—a rude sort of billhook—very badly made, I confess, so badly that I brought it home to have a few better one made for use in my own garden. But the native is content with it, and refuses to give more than a penny or two extra for one of the best English make. If, however, a slightly better article (without any attempt at finish) could be provided at no very great extra cost, and of the same weight and appearance as this native implement, it might be accepted, and if accepted (this is the point), would be taken in hundreds of thousands. This is the direction in which English manufacturers would, I believe, have the best chance, if they have any chance at all, of entering the Indian market for some years to come.

I may conclude this part of my subject by quoting some words of advice addressed by Lord Ripon to the recently formed Agricultural Department. "In dealing with agricultural improvement," it was written, "the earliest ambition of the Department should be to secure the active aid of those members of the native community who are sincerely interested in agriculture. It is, after all, only through and by the native community that agricultural improvements can, on any important scale, be effected. Native gentlemen have experience and facilities for extending improvements which no official can hope to obtain, while in many provinces they have a large amount of capital available for investment in agricultural enterprise. They are familiar with the usages of the cultivating classes. They understand the existing system of Indian agriculture, and they are often acquainted with the local reasons which justify practices that may seem strange and illogical to a European observer. They can, therefore, best guide the course of agricultural improvement with the least disturbance of existing circumstances, and develop the true policy of progress in improving and adding to indigenous conditions, without that subversion of ideas and methods which is likely to accompany the introduction of exotic reforms. To secure their co-operation, therefore, is an important object. Nor must it be forgotten that a further valuable source of information and advice exists in the European community of planters and landlords, who have already given a useful lead to native enterprise in the adaptation of western appliances to the agricultural system of the east.

"The views of the Government of India may be summed up by saying that the foundation of the work of an Indian Agricultural Department should be the accurate investigation of facts, with the view of ascertaining what administrative course is necessary to preserve the stability of agricultural operations. It is desired, therefore, that the new departments should be so constituted as to give the fullest effect to this policy. The primary efforts of the departments should, when established, be devoted to the organisation of agricultural inquiry, which has been shown to comprise the duties of gauging the stability of agricultural operations in every part of a province, of classifying the areas of the province according to the result of careful investigations, and of deciding what method of administrative treatment is suitable to each, so as to maintain agricultural operations up to the highest standard of efficiency possible under present conditions. From a system of agricultural inquiries thus conducted will follow the gradual development of agricultural improvement in its manifold variety."

May I tax your patience with one word more about the "indebtedness of cultivators." I only wish to say that it is absolutely necessary that five-acre holders should be protected by capitalists when the out-turn of their farm is a mere matter of guess; and since, as a rule, the whole of the capital which comes into the money-lenders' hands, in the form of interest, mortgages, and so on, is at once returned to the land, to sustain agricultural operations, the position is not so bad as it is sometimes represented. The best, if not the only way, of keeping the cultivators out of the capitalists' hands, and of giving an industrious farmer the chance of being his own banker, is to eliminate, as far as possible, the uncertainty which now attends his harvests. In Eastern Bengal, for instance, where the out-turn is tolerably certain and secure, the condition of the cultivator leaves little to be desired. This leads me to utter, in conclusion, one word of warning, viz., that no one should accept as true of all India that which is asserted of any one part of it. Even we in India grow more and more diffident, the longer we stay there, of making any general assertion as applicable to the whole country or even to any one province. To go back to my unit of measure, everyone of our Indian Egypts has a different climate and different crops; different races of cultivators, differing in character and generally in language; pursuing

agricultural systems varying more or less the one from the other, and subject to different systems of revenue and rent. It is true that in some of these units the condition of the cultivator is worse, much worse, than in others. It is sometimes deplorable. But where it is so, it is due, I am convinced, not to the cruel treatment that he receives from his British rulers and their representatives, but from his mistress, Nature, and her capricious monsoons, against the tyranny of which every nerve is now being strained to protect him. I cannot help reminding you again, that the efforts of Government in this direction received an important and effectual impetus from the mission sent out by the people of England, of which Sir James Caird and General Strachey were the leaders. Much, very much, remains yet to be done. But though the work of protection is far from being accomplished, rest assured of this, that whatever pictures may be drawn of local distress in some parts of India, in the greater part of the Empire the condition of the cultivators is materially better than it was fifty years ago.

DISCUSSION.

Mr. W. S. Seton-Karr said he was glad to find that Mr. Buck did not lay too much stress on Government model farms, which were sometimes put forward as a panacea for all defects in Indian agriculture. They might do good in a certain way, in showing intelligent landowners how to improve their breed of cattle, and to vary their produce ; but he was glad to hear it acknowledged that, in many points, we had as much to learn from the Indian agriculturist as we could teach him. He had always known that he was diligent, industrious, and skilful, and that he understood the use of manure, its absence being accounted for by the poverty, not the ignorance, of the cultivator. It has been hastily said by some, that with a little trouble and scientific teaching, the productive power of India might be increased from 50 to 60 per cent. ; but this view rests on conjecture, nor did Dr. Hunter favour it in his statistics. He thought it likely that if there were a sufficient rainfall, and the peasantry were not so much indebted, they would give more time and labour and might increase the product from 10 to 15 per cent. That had been his own experience. He found also that the native was not very quick at taking up new agricultural implements: you would never get him to use any plough which he could not put on his shoulders and take home every night. He had seen experiments with steam ploughs in the neighbourhood of Calcutta, which turned up the ground two and three feet in depth, but a five-acre cultivator could never be expected to use such expensive machinery. Something, no doubt, might be done to improve the breed of cattle, which had considerably deteriorated of late years. In some parts of Bengal milch kine were used for ploughing, which must interfere with the proper nourishment of the calves, and result in a degenerate and puny breed of cattle. In some parts, however, as in Goojerat and Hansi Purnea, there were cattle of a magnificent size. He thought the reclamation of waste lands should be left to zemindars or cultivators themselves ; and with regard to migration, he was quite satisfied that there were parts of India—Assam, for instance—which were capable of supporting a much larger population than they now did.

Mr. Wilson said he might state the effect of various experiments which had been made by the Agricultural Department in the North-West Provinces, with a view to cleansing saline lands there. This land was of two classes, the high land between the rivers, and the low land near the rivers, the former being the more important of the two. The soil was a clayey loam of light colour, very impermeable to water, and very difficult to till. If disturbed, there was no true tilth; it simply broke up into small lumps. The surface was covered in places with efflorescence, in others quite bare, but for the most part covered with a short grass, which the natives called *oosa* grass. If a pit were dug in an *oosa* plain it was found that this stratum of clayey soil was generally about three or four feet thick, frequently underlaid by a stratum of sandy loam quite free from excess of saline matter. The line of demarcation between the two was often very clearly marked, but in some cases one merged into the other, both being of nearly the same chemical composition. The experiments which the Agricultural Department of the North-West Provinces had conducted included manuring, flooding with canal water, surface drainage, subsoil drainage, the growth of special crops, and arboriculture. As far as making the land suitable for growing ordinary crops, while the experiments had not had very much success, a most successful attempt had been made by the Irrigation Department. They had turned canal water over some *oosa* plains, and the silt contained in the water being deposited to a thickness of twelve or eighteen inches, had been found sufficient to permit ordinary crops to be grown. He had seen wheat crops growing on silt, certainly not more than eighteen inches thick, on the very worst land of this description. That was the only case he knew of actual reclamation, but the utilisation of this land was certainly possible. The ordinary *oosa* plain was simply covered with short grass, which was very good for fodder, and by keeping the cattle away from it, the grass grew rapidly, and spread over the worst and most efflorescent patches. It was perennial grass, having very deep roots, sometimes as long as five feet. Some of the trees which had been planted promised to be

successful. The ordinary acacia of Africa, which grew a great deal in Egypt, as well as in India, had not proved successful, for, though it seemed to do well for a few years, trees had lately died off. An Australian salt bush had been tried, and that certainly grew well, but whether it would prove of much use as fodder remained to be seen. Last year only about twenty trees yielded fodder; but some more seed had been imported, and the result would be known in a few years. A proposal had been laid before the Government to utilise this land, by fencing off large portions, planting them with trees in the better parts, and leaving the rest to grass, and this, he thought, would be beneficial, as it would stop denudation, and cause an accumulation of humus in the soil, which was now the great want. He had lately had the privilege of meeting Dr. Hillyard, Professor of Agriculture in the University of California, who had been studying this question of alkaline lands, and had discovered one or two points which had not been noticed in India. The most important was the different effect of different kinds of salts. They were all soda salts, sulphate, chlorate, and carbonate, in different proportions, and Dr. Hillyard found that the sulphate and chloride had from ten to twenty times less effect than the carbonate, that was to say, the soil would stand ten or twenty times more chloride or sulphate than it would carbonate. The limit of the carbonate of soda was about five parts in 100,000, so that the sulphate or chloride might amount from five to ten to a thousand. If this were so, the most important thing to do was to get rid of the carbonate; nearly all the salts contained some of it; in some cases, the sulphate was in excess, in others the carbonate, but nearly all contained some carbonate. Professor Hillyard's antidote was gypsum, which he sowed before the seed was put in, of course water being used at the same time; that converted the carbonate into sulphate, which was comparatively inert.

Professor WRIGHTSON asked if the efflorescence returned again if it were once destroyed; or if the salt were once converted into sulphate, whether it was a permanent improvement?

Mr. WILSON said the efflorescence could be kept down; it was brought up from below by capillary attraction, and was kept down by cultivation, or by getting some crops to grow on the ground. In reply to a further question, he said he did not think it would be possible to get rid of it by lowering the water table, which was quite low enough already.

Mr. REID said it had been said that the productive power of the soil of India could not be improved or increased, and that there were no means at the disposal of the ryot of improving it. He had been in India close to a saltpetre manufactory, close to which he had plucked up a wheat plant having eighty-nine branches, and which weighed in its green state 640 drachms, or $2\frac{1}{2}$ lbs. Only 12 ft. from this plant he took up another, which weighed only $4\frac{1}{2}$ drachms, and had only two branches. This showed what an effect manure had on the soil of India. All this saltpetre was manufactured in Behar, and the adjoining districts, and was exported from the country, and with it the very essence of the manure. He agreed with Mr. Buck as to the value of irrigation, but still irrigation was something like dram drinking, it might often be applied too largely, especially in hot weather. When the atmosphere was dry, it increased the capillarity, and raised the salt, which was dangerous. The saline efflorescence was very much worse in the driest parts of India, in the north-west and Panjab, than in the lower provinces, where the rainfall was heavy.

Sir HUGH LOW, K.C.M.G., said he had had the pleasure of meeting Mr. Buck when on the mission to Siam to which he had referred, and he was thoroughly satisfied that there was a great field for emigration there. They got large numbers of Chinese, who were very useful for many purposes, but they did not take much to agriculture. The object of the Chinese seemed to be to make money as quickly as possible, and mining paid them better than agriculture. When Mr. Buck was there, it seemed to be a question with the Indian Government whether its subjects should be permitted to migrate freely to this land of promise, where Mr. Buck saw them earning wages far beyond anything they could get in India; where they were well fed, well clothed, and although they were not so well housed as he should like them to be, the climate was genial, and the housing was not of much importance. That country was very anxious to induce them to come, and since he left, a year ago, the regulations were so modified that there was a fair chance now, he believed, of getting a sufficient supply of labour, which was the only thing necessary for cultivation. An ordinary man from Madras, who got in his own country 6 to 7 rupees a month, would easily get 12 to 15 dollars a month in Perak; and it seemed very remarkable why there should be so much difficulty on the part of the Indian Government in allowing its subjects to go there, for even now he believed it would be very difficult for planters to import anything like the numbers they would like. He should like to see free emigration permitted. There was sufficient protection for life and property in the Malay States, which were under British protection, and he could not understand why there should not be perfect freedom for the people of India to go there, if it were found that they could better themselves, and live more comfortably, and add to the wealth of England, by fostering the cultivation of those provinces, which were in fact English, though they were called native states. This was the point to which Sir Frederick Weld's Government at the Straits Settlements had given a deal of consideration, and he thought everyone who considered it fairly would agree that everything ought to be done to induce the Indian Government to look at

it in the proper light. The land such as Indian settlers would occupy was very fertile, and it was no uncommon thing to see paddy produced two hundred and two hundred and fifty fold, with a minimum of cultivation, on lands some of which were irrigated and some cultivated entirely by the rainfall, which was very heavy. The only cultivation he had ever seen the present occupiers of the soil use was cutting down the weeds in the beginning of the rains. The most approved system was to drive a herd of buffaloes over it, to drive the weeds in. There were some salts, but they could not be much in excess, as he had seen the finest sugar-cane growing where the soil was quite white with efflorescence, which he thought was caused by carbonate of soda. It was found that if plenty of water were put on the land it washed the salt away, or converted it into manure. The Government was most anxious to favour Indian labourers coming into the State, and had offered to give them land on almost any terms, if they could only get them to come and settle down as permanent cultivators; or if they would not do that, they were willing for them to come there, and return to their own homes, to which they always carried back considerable wealth after having lived in comfort and happiness all the time they were there.

Mr. W. G. PEDDER said, with reference to the question of increasing the productiveness of the soil of India, there was a good deal of misapprehension. In some parts, the more fertile and better cultivated, there could, under ordinary circumstances, be but a very small increase, and he knew tracts in which it would be extremely difficult, without much more scientific cultivation, to raise a little more than was raised at present; but, on the other hand, there were very large tracts in which a very moderate increase of skill and labour amongst the people themselves would very greatly increase the productiveness. He could mention several instances in which, in the same region, there was an enormous difference in the amount of productiveness, owing to greater efficiency and energy on the part of the superior races among the cultivators. With regard to irrigation, Mr. Buck very properly laid great stress on irrigation from wells constructed by the people themselves, which was the very best kind of irrigation. There were many parts where canal irrigation was inevitable; but where there was water available by wells it was more useful, better economised, injured the land less, and gave better crops than canal water. But there were numerous difficulties in the way of inducing people to improve their land by well irrigation. As Mr. Buck had pointed out, through a great part of India the holdings were generally about five acres. Now, a well with two buckets, 30 to 35 ft. deep, was generally supposed to be able to irrigate seven acres; it was not worth while to make a one bucket well, because it cost as much as one for two buckets, and of course it was obvious that on every five acre lot there was water enough for two acres to spare. Of course the occupier might let to his neighbour, but that immediately raised questions between the holders, and between them and their landlords, which frequently ended in resort to court, the usual result being the ruin of both parties.

The CHAIRMAN, in proposing a cordial vote of thanks to Mr. Buck for his very able, graphic, and interesting paper, remarked that that gentleman, as the head of this new department, had shown that he had obtained a thorough grasp of the whole subject, which must give great confidence to those who had placed him in that very onerous and responsible position. Beginning as he had, with the question of the permanent settlement, it must be agreeable to those who had had any experience of India, to think that a termination was about to be made to that attempt periodically to do that which was really impossible, viz., to fix a value upon soils in which, whatever the experience of the officer might be, it was impossible that he should be able to tell whether one soil or another was worth one rupee more or less than that by the side of it. Nothing had, in his opinion, more tended to prevent the development of agricultural improvement in India, than the fact that cultivators of the ground knew that if they succeeded in making considerable improvements, at the end of the period when the new valuer came round to assess the land, and the amount the cultivator could afford to pay to the landlord or the State, the improvements he had made with his own skill and labour, and perhaps with the little capital he was able to command, were employed against him to raise the assessment. It was most satisfactory to find that one of the earliest proceedings under this new department, seemed to be the commencement of a system by which these periodical valuations should cease, and a new principle be adopted, by which the cultivator would be allowed to keep the full benefit of every improvement made by his own skill or labour, and, if it were necessary at certain periods, to give an addition to the Government or to the landlord, that would be founded only on something which had happened outside of him, by the introduction of railways, or facilities of obtaining irrigation. It would be most important, also, that the Government should make a condition with the sub-landlord to secure to the five-acre men, who were scattered over the whole of India—the real cultivators of the soil—the same measure of justice and fairness as they had given to the zemindars who stood between the Government and the cultivators. Mr. Buck was confident that the agricultural resources of India were capable of great improvement, and he need hardly say that it must be so, because every ten years there were at least 20,000,000 more mouths to fill, by the natural increase of population, which must demand a very considerable in-increase in the present produce of the soil. They

would, therefore, hopefully look forward to the gradual improvement which they trusted to ensue on this new principle of the re-assessment of the land. The magnitude of the country which Mr. Buck had graphically pictured to them by comparing it to Egypt was very interesting. He said that India had fifty times the population and fifty times the extent of cultivated land of Egypt. In one great point India was inferior to Egypt, as it had not the advantage of the waters of the Nile, which periodically not only watered but enriched the soil; but there was another important point in which India had an advantage over Egypt, viz., the pressure of debt. In India the debt, if you deducted that portion which was invested in great public works, was very little more than a single year's revenue; but the debt of Egypt, which exercised a ruinous pressure on the country, was something like fourteen years' revenue. So that, comparing the two countries in that way, something at least of the advantage which Egypt had in the Nile was compensated for in India by the very small extent of the public debt. He had been much struck with the description Mr. Buck gave of the Indian cultivator. In every part of India which he visited, where he took pains to go amongst the cultivators, and see what their condition really was, he was much struck, not only with their patience and industry, but that wherever they had land which was capable of yielding crops, and where there was an adequate natural or artificial supply of water, he found the cultivation as clean and good as he had seen in any country—garden cultivation, in fact, in many parts, such as one would rarely find in many parts of Europe. On one occasion, in the Punjab, he went into a field which was being prepared for wheat, and was quite surprised at the ingenuity with which the men were not only managing the plough, but each also had a cane pipe, which ran down behind the plough, into which, as he walked along, he dropped single grains of wheat, which fell behind the plough as he proceeded, and was covered over. No drill in the world could do the work better than that simple arrangement by which the native cultivator did his work. Mr. Buck had described the great difficulty and danger which arose in India from the unequal distribution of rainfall, and its too frequent absence in certain quarters; and described the country as being split up into five-acre farms. Now, as there were about 200,000,000 acres under cultivation, that represented 40,000,000 small farmers, who, with their families, formed four-fifths of the whole population. That showed the great importance of the agricultural interest of India, and how necessary and proper it was that due attention should be paid to it. They must all be pleased to find that Mr. Buck had been placed in the high and honourable position which he now occupied, and he had no doubt he would prove himself worthy of it. Such vast interests fully justified the proposals of the Famine Commission, and it was, as Mr. Buck explained, very much in consequence of the recommendations of that Commission this department had been founded, or rather re-created and enlarged. Speaking of the important subject of irrigation, he agreed with Mr. Pedder that where wells could be got at a moderate distance from the surface, say 30 feet, and could be economically worked, there was probably no system so perfect as that where each little farmer, with his well, could command a supply of water for such portion of land as he required, and whenever he did require it. In speaking of the canal irrigation, Mr. Buck did not refer to the great distinction between the north of India and the south. In the northern canal irrigation, the water came from the melted snows of the Himalayas, and on examining the deposit which was cleared out from the Ganges canal, and placed in large mounds near the banks, he found it was nothing but clear sand, which, if it had flowed over the soil, would have seriously deteriorated its quality, instead of improving it. In the south of India, on the other hand, the whole of the canal irrigation, which was most successful many years before we had any connection with India, and was noticed by Sir Arthur Wellesley in 1804, came from the monsoon rains, and not from the snow mountains, and brought down a deposit which was of an enriching quality.

Mr. PEDDER—And which was apt to fail.

The CHAIRMAN said that might occasionally be so, but there was this great distinction between the quality of canal water in the north and in the south. The advantages to be derived from railways had been clearly shown, as also those from the improvement of the revenue land system, the reclamation of waste lands, and irrigation. He did not think the Indian people emigrated—that was to say, went away without the intention of returning. It was with them a question of migration, and he believed there were large portions of India where there was room for extensive migration still from the over-populated tracts, especially Assam and Burmah, even without going a little further to Perak, the region Sir Hugh Low described, and which seemed to be an exceedingly attractive one. There was another great dependency—Australia, in the northern part of which there was a sub-tropical climate, where sugar might be grown with great success, the only drawback being the want of labour. If arrangements could be made with the people of Queensland satisfactory to the Government, there was an immense field for the migration of any surplus population from the southern parts of India. In a judicious promotion of each of these remedies would be found the truest safe-guard for the continued progress of India, and its best protection against famine. For the members of the Famine Commission as for himself, it was an especial comfort to find that each one of these objects was, after full consideration by the Commission, pressed on the attention of the Government with a clearness and force to which they were indebted to their secretary, Mr. Elliott, now Chief Commissioner of Assam. He hoped to have seen

the chairman of the commission, General Strachey, present, for he was sure to him, as well as himself, the remarks of Mr. Buck would have been agreeable; to Lord Ripon, by his acceptance of the recommendations of the Commission, belonged the honour of grasping the true position of the country, and of having, during his viceroyalty, laid the foundation of principles which, if carried out, must largely contribute to the growing prosperity of India.

The vote of thanks having been carried unanimously,

Mr. BUCK, in reply, said, with reference to restrictions on migration, Sir Hugh Low would be glad to hear that, since he left the Straits, the Government of India had done everything it could to remove obstructions to emigration to the Malay Peninsula. The same thing had occurred with regard to Australia, and he was sure that the improvement of native labour there would give employment, as overseers and in similar capacities, to numbers of Europeans, who could not now get employment in the north of Australia at all.

FOREIGN & COLONIAL SECTION.

Tuesday, January 27, 1885; General SIR J. HENRY LEFROY, K.C.M.G., C.B., F.R.S., in the chair.

The paper read was "With the British Association in the Canadian North-West," by STEPHEN BOURNE.

The paper and discussion will be published in next week's *Journal*.

EIGHTH ORDINARY MEETING.

Wednesday, January 28, 1885; ROBERT JAMES MANN, M.D., F.R.C.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Boucneau, Adolphe Joseph Henry, 48, Warren-street, Fitzroy-square, W.
Boustead, —, 34, Craven-street, Strand, W.C.
Fraser, Robert Alexander, 2, Russell-chambers, Bloomsbury, W.C.
Michael, Colonel, C.S.I., Bangor-lodge, Ascot.
Rhodes, John George, Oakdene, Brackley-road, Beckenham, Kent.
Robson, Frederick, Young Men's Christian Association, Mill-lane, Stockton-on-Tees.
Wingfield, Charles Humphrey, 26, Upham-park-road, Chiswick.

AND AS AN HONORARY CORRESPONDING MEMBER.

Mueller, Baron Ferdinand von, K.C.M.G., Ph.D., F.R.S., Melbourne, Victoria.

The following candidates were balloted for and duly elected members of the Society:—

Barrett, William Lewis, 17, Steyne, Bognor.
Bousfield, William Robert, M.A., 4, Crown Office-row, Temple, E.C,
Cooper, Henry William Alexander, Pretoria, Transvaal, South Africa.
Dahl, Robert Hutchinson, Morden-lodge, Putney.
Duncan, William Henry, Coalbrookdale, Shropshire.
Garrod, Edwin, 22, Great George-street, Westminster, S.W.
Hirsch, Gustav, Wanderers' Club, Pall-mall, S.W.
Institute of British Carriage Manufacturers (Secretary), 16A, Great Queen-st., Lincoln's-inn, W.C.
O'Donovan, D., Brisbane, Queensland.
Oliver, Robert Stewart, 19, Ness-bank, Inverness.
Orme, Robert, 29, Collingham-place, S.W.
Peacock, W. P., 51, Water-lane, Brixton-rise, S.W.
Priestman, John, 25, St. Charles's-square, Notting-hill, W.
Skinner, Richard, 6, Park-road, Bromley, Kent.
Turner, Barrow, 37 and 38, East-street, Manchester-square, W.
Wakefield, Henry Tyndale, Metropolitan Board of Works, S.W.
Webster, Miss, 3, Sydney-villas, Richmond, Surrey.

The paper read was—

THE INFLUENCE OF CIVILISATION UPON EYESIGHT.

By R. BRUDENELL CARTER, F.R.C.S.

A few months ago, through the channel afforded by the columns of the *Times*, I endeavoured to direct public attention to the influence of civilisation upon eyesight; and the present paper must be regarded as a continuation of that endeavour, entered upon in circumstances which will permit me, in some respects, to be more explicit than the space formerly at my disposal would allow. The principle which I wish to lay down is that the functional perfection and activity of human organs, or, indeed, the functional perfection and activity of organs throughout the animal kingdom, are dependent upon the manner and degree in which those organs are exercised; for, while efficient exercise of them not only produces improvement in the individual, but also tends towards improvement in his offspring, so limited or imperfect exercise tends towards deterioration, alike in the individual and in the race. These assertions, indeed, are but expressions of facts which are universally recognised by those who have given any thought or study to questions of development; and they are illustrated, not only by the excellence attained, throughout the animal kingdom, by those organs upon which any creature depends for the capture of its

prey, or for defence against its enemies, but also, and in an equal degree, by the many instances in which organs or parts, which are active and useful in some species, have become rudimentary in others. The truth seems to be that we have around us, on all sides, not only evolution, but also involution; and that there is no such thing as finality in Nature. On every side the old order of things changeth, giving place unto the new; and, on every side, the new may be either better or worse than the old. It does not follow in physiology, any more than in morals or politics, that change must of necessity be conducive to improvement.

Our eyes are an inheritance from a very remote ancestry. If we look back over the ample page of the history of development, so far as that page has been unfolded to us by the genius of Darwin, we learn that the fitness of living creatures for their surroundings has gradually arisen from the advantages conferred by favourable variations of construction; which variations, by the operation of the law of inheritance, have been handed down to offspring; so that, for example, when any kind of animal had developed, possibly as an accidental variety, eyes better adapted to the supply of its wants, and to the conditions of its mode of life, than the eyes of its congeners, that animal, thus improved, would have a better prospect than they of leaving healthy and vigorous descendants behind it. I should be detained far beyond the limits of my allotted time, if I were to attempt even a sketch of the doctrine of evolution by the survival of the fittest, as applied to the history of development; but I may say that our power of understanding the main features of the process is materially assisted by the fact that the young of all species, in their growth prior to birth and independent existence, may be said to crowd together, into a few weeks or months, changes which present a general resemblance to those through which the species itself must have passed in the course of ages. By watching the processes of growth and formation in the embryo, it was long ago ascertained that the eyes of animals consist essentially of modified skin, the necessary modification being produced only in the skin which covers a particular nerve, and being adapted to expose that nerve freely to the action of light, to systematise this action in such a way as to afford pictures of external things, and at the same time to protect the nerve from all other kinds of stimulation.

Speaking broadly, it may be said that the nervous system of the human body is an apparatus sensitive to vibration; and that the vibrations to which it is most exposed are those produced by, or conveyed through ordinary contact; those produced by the vibration of the air, which is recognised as sound; those produced by the vibrations incidental to the occurrence of chemical changes, which are recognised as smell and taste; and those produced by the vibrations of the all-pervading ether, which are recognised as light. If we come to analyse the nervous system, we shall find, in highly developed animals, that it is specialised: in the sense that its really perceptive parts, which are called centres or ganglia, each take cognisance of only one kind of impression; that these parts are deeply buried in protected regions, as within the skull or the spinal column; and that they are dependent for their communication with the external world upon filaments, which are called nerves, to distinguish them from the ganglia. All this specialisation, however, is of comparatively recent date; and in the lower forms of life we find that the nervous centres are less protected, less collected together, more scattered throughout the animal, and presumably less specialised than in the higher forms; until, when we reach creatures which approach the confines of the vegetable kingdom, we find a sort of diffused sensitiveness to vibration, which hardly seems to be gathered up into nervous centres at all. We need not go back so far as this; but in tracing out the development of the eye, we must carry ourselves, in imagination, to a time when the highest form of life upon earth was an animal in which there were nerve ganglia, with or without filaments proceeding from them, but protected by a covering of skin; and we must conceive that some of these ganglia were capable of feeling the action of light, that is to say, of tingling when exposed to the rays of the sun. We need not look far for an illustration of such a state of existence, for we have it in the common earth-worm of our fields and gardens. The earth-worm has no eyes, no rudiments even of eyes, but it is sensitive to light. It is, as we all know, a creature of nocturnal habits, and birds prey on it with such avidity that these nocturnal habits are essential to its preservation. An earth-worm which was insensitive to light, and which ignorantly came out of its burrow to feed in the daytime, would inevitably be devoured before evening. That the sensitiveness is really to light, and not to the heat of the sun, or to any other diurnal incident, may be con-

cluded from probability, and has been demonstrated by experiment. In our climate there are many dull damp days on which worms would not feel any effect of the sun in depriving them of moisture, or in the form of heat, but during which, nevertheless, they remain in their holes. As soon as it becomes dark, if we go out upon a grass-plot with a lantern, we may see worms feeding by scores, their tails still keeping hold of the mouths of their burrows, and their bodies extended as far as possible. The feeble light of the lantern does not affect them; and by moving about with great gentleness we may watch their actions. If we give a stamp of the foot, we shall see how sensitive they are to vibrations produced by contact, for they will disappear into their holes with marvellous rapidity. In order to determine whether they were sensitive to light, Mr. Darwin experimented in the following manner. He kept some worms in flower pots, in suitable mould, so that he might be able to observe their conduct. When they were out at night, and feeding, he illuminated them by a bull's-eye lantern having slides of dark red and blue glass, which intercepted so much light that the worms could only be seen with some difficulty. They were not at all affected by this amount of light, however long they were exposed to it; and Mr. Darwin judged it to be brighter than that from the full moon. The colour of the light appeared to make no difference in the result. When they were illuminated by a candle, or even by a bright paraffin lamp, they were not usually affected at first. Nor were they when the light was alternately admitted and shut off. Sometimes, however, they behaved very differently, for as soon as the light fell upon them they retreated to their burrows with almost instantaneous rapidity. This occurred, perhaps, once out of a dozen times. When they did not withdraw instantly, they often raised the anterior tapering ends of their bodies from the ground, as if attention was aroused or as if surprise was felt, or they moved their bodies from side to side as if feeling for some object. They appeared distressed by the light; but Mr. Darwin doubted whether this was really the case, for on two occasions, after withdrawing slowly, they remained a long time with their anterior extremities protruding from the mouths of their burrows, in which position they were ready for instant and complete withdrawal.

When the light from a candle was concentrated by means of a large lens on the anterior extremity, they generally withdrew instantly; but this concentrated light failed to act, perhaps, once out of half-a-dozen trials. The light was on one occasion concentrated on a worm lying beneath water in a saucer, and it instantly withdrew into its burrow. In all cases the duration of the light, unless extremely feeble, made a great difference in the result; for worms left exposed before a paraffin lamp or candle invariably retreated into their burrows within five to fifteen minutes; and if in the evening the pots were illuminated before the worms had come out of their burrows, they failed to appear.

From the foregoing facts, says Mr. Darwin, it is evident that light affects worms by its intensity and by its duration. It is only the anterior extremity of the body, where the cerebral ganglia lie, which is affected by light, as was observed on many occasions. If this part is shaded, other parts of the body may be fully illuminated, and no effect will be produced. As the animals have no eyes, we must suppose that light passes through their skins, and in some manner excites their cerebral ganglia.

It becomes evident on reflection that, in the case of an animal situated in this way, its food supplies might be increased, or might be rendered more accessible, by any change which rendered it more sensitive to light than previously. It is also evident that such a change might be structural in its character, as by a thinning out or an increased transparency of the skin by which the nerves sensitive to light were protected; and that, in this case, it might not only conduce to the more vigorous growth of the animal immediately affected, but would also be of a kind to be handed down to its offspring, both immediate and remote. Other things remaining the same, the individuals in which the nerves sensitive to light were covered by the most transparent skin, so that the light had the readiest access to them, would have the best chances of survival and of propagation. As time went on, successive individuals would be born with slight departures or differences from the parental structure; and every difference of this kind would be either favourable or unfavourable, either advantageous or disadvantageous to its possessor. In other words, every change would be either for the better or for the worse. A change for the better would act in the manner already indicated; that is to say, it would confer advantages in the battle of life, or, as Mr. Darwin called it, in the struggle

for existence; a struggle of which the essential characteristic seems to be that there are always more mouths to be fed than there is food to fill them, so that the weakest and worst-provided must go without, or must even, in many instances, be themselves devoured by their more fortunate competitors. A change of structure for the worse would reduce the subjects of it to a weaker condition; so that, instead of living and propagating their kind, they would be likely to fall victims to others, and might even perish off the face of the earth.

This great doctrine of the process of natural selection, when first propounded by its illustrious author, was received with an incredulity which mainly rested, I think, upon the supposed inadequacy of the means to bring about the end; but this incredulity has long passed away from the minds of those who are best qualified to judge upon the questions at issue. It is now admitted by all biologists that the aggregation of countless trivial changes for the better, and the rejection and perishing of changes for the worse, have, in time, sufficed to bring about all the forms and conditions of existence which surround us; and the more thoroughly the process described by Mr. Darwin is scrutinised by the eye of science, the more does its adequacy, when acting through long periods of time, become apparent. To this process the members of the animal kingdom generally, and man himself, are indebted for those eyes which we are accustomed to regard as among the most marvellous and the most valuable portions of our bodies.

Setting aside minor differences, the development into eyes of the skin which covered certain cerebral ganglia has followed two totally different lines of direction. There are the compound eyes of insects, which may be likened to a large number of fixed telescopes, radiating from a nerve centre common to them all; and there are the moveable eyes which are generally found among vertebrata. It must be remembered that the evolution of the moveable eye has not been an achievement of the human race, but that it had been carried to a high degree of excellence long before the appearance of man upon the globe. We inherit the eye, in all its essential parts, from an ancestor not only remote, but also common to ourselves and to a large proportion of the animal kingdom; and I think there can be no doubt, not only that the organ, as civilised men now possess it, is inferior to that possessed by animals which we have far outstripped in other particulars, but also that, amongst ourselves, it has fallen very decidedly below the standard of excellence which it has attained in some of the families of the human race. In my communication to the *Times*, already mentioned, I referred to a well-known incident recorded by Humboldt. He was travelling in South America, under conditions which rendered it necessary for the party to divide, and to reach their destination by different routes. As he and those who remained with him approached the appointed meeting place, he said to the Indian guide that he wondered what had become of the others. The guide looked at him with some surprise, and, pointing across a valley some miles in width, one side of which the party were traversing, replied—"There they are." Humboldt himself could see nothing but mountains and verdure; but ultimately, being assisted by the guide as to the position of the other party, succeeded in discovering them by the aid of a telescope; and then, by making the guide describe the order of march and the occupations of the several individuals, obtained proof that he actually saw them with his unaided eyes. After my letter appeared, Mr. Hoskyns Abrahall wrote to mention that Arago, in Central Asia, met with a Tartar who described to him an eclipse of Jupiter's third satellite. The man said that he seen the big star swallow a little one, and spew it out again. An experience of equal significance, if of a less striking character, may be had in any Highland forest, where deer, which are conspicuous to the eyes of the forester, can only be seen with difficulty and uncertainty, and after much pointing out of neighbouring landmarks, by visitors who are habitual dwellers in towns. In other words, the acuteness of sight of the average citizen is much inferior to that of the average Scotch forester; while the acuteness of sight of the forester is probably much inferior to that of the savage. There are two aspects under which the fact may be regarded. It is possible to think of the forester or of the savage as the possessor of some special acuteness which has been conferred upon him by training and practice; and it is possible to think of the citizen as a person who, by reason of unfavourable circumstances, falls short of the acuteness of vision which he ought to possess. I hold the latter view, partly because the neglect of vision among urban dwellers, and its consequent decadence, are matters about which there can, I fear, be no dispute; and partly because this is the only direction in which

physical superiority on the side of the savage is apparent. Young men of the present generation, dwellers in towns, and of English or Anglo-Saxon race, have surpassed, in physical strength and endurance, all that has been done in other countries or in former times. Nearly fifty years ago, Lord Eglintoun attempted a revival of the tournaments of the Middle Ages; and a number of gentlemen clad in armour, and mounted on horseback, undertook to tilt at one another in lists erected for the purpose. They were mostly men of old family, in whose mansions ancestral armour had been preserved, and the first idea was that such ancestral armour should be worn by each knight at the tournament. It was found, however, in almost every instance, to be too small for the descendants of its original owners. In like manner, the athletic feats of our own time are such as have never been performed before. It is not so many years since Captain Barclay, who walked a thousand miles in a thousand hours, surpassed all previous pedestrianism; but he in his turn has been surpassed, nay distanced, by the feats of pedestrian endurance which have been performed at the Agricultural-hall. Deerfoot, the Indian, who came to England to run races, was beaten out of the field by English runners. Leander, it is said, swum across the Hellespont; and so, in modern times, did Lord Byron, and Captain Ekenhead, and Mr. Hyett; but it was reserved for Captain Webb to swim across the English Channel. We may extend the comparison far beyond the ranks of professional or amateur athletes. The dwellers in the poorer portions of our great towns, and especially our factory operatives, often living in very unwholesome conditions, with scanty supplies of light and air, and subject to other deteriorating influences, are not, when taken alone, the finest specimens of humanity; but there can be no question that they are greatly superior to their ancestors of fifty years ago. It is a safe assertion that the general physical development of Europeans, and of Americans of European descent, is better than it has been at any previous period.

When we come to consider the state of vision, the facts are less pleasing to contemplate; and, although we have not all the data which would be required for complete knowledge of the subject, we have enough to point out the necessity of attending to it. An enormously large proportion of the whole German nation is composed of the wearers of spectacles, and there is abundant evidence that the need for such assistance dates from a comparatively recent period. In 1812, the late Mr. Ware communicated to the Royal Society the results of some investigations into the sight of different classes of people in this country, and he stated that, in the three regiments of Foot Guards, short sight was "almost utterly unknown." During twenty years, and among 10,000 men, not half-a-dozen soldiers had been discharged, nor half-a-dozen recruits rejected, on account of it. In the military school at Chelsea, among 1,300 children, he found that there were no complaints of short sight, and, on closer investigation, there were "only three children who experienced the least inconvenience from it." Last year, my friend and colleague, Mr. Adams Frost, was good enough to examine for me a Board school in the South of London, and he found that 73 children out of 267, or rather more than one-fourth, had defective or subnormal vision. Among these 73, 26 were short-sighted, 16 were flat-eyed, and would thus be called upon for unnatural exertion in the act of seeing, exertion which cannot fail to tell upon them in after life, or even before they leave school. In 1865, in Germany, Professor Cohn examined the eyes of 10,060 school children, and found 1,630 of them with eyes of faulty shape. Of these, 1,072 were short-sighted, 139 were flat-eyed, 23 were the subjects of a complicated defect of shape called astigmatism, and 396 were suffering from the results of previous disease. I offered the School Board for London to undertake an equally extensive investigation, but my offer was declined in an uncivil letter, written in very bad English. I cannot doubt, however, from the incidental sources of information at my command, that the conditions found in one school by Mr. Frost would, at least approximately, be repeated in many others.

If we inquire the reason why the eyes should undergo deterioration, while other physical organs are steadily advancing in vigour and development, I think we shall find the explanation to be twofold. In the first place, as I shall presently explain more fully, the constant use of the eyes on near objects is injurious to them. In the second place, the deterioration is partly due to popular ignorance on the subject of what the eyes ought to be able to accomplish. All that is required, in order to bring about their improvement, is the direction to them and to their functions of the same amount and kind of attention which is at pre-

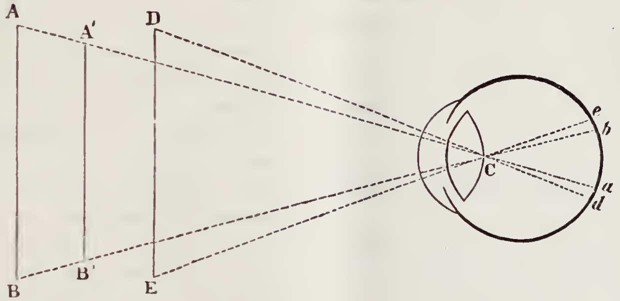
sent bestowed upon other physical capabilities of the human race. What I may fairly describe as national neglect of the culture of the eyes, and of efforts to improve the faculty of seeing, is chiefly due to the prevailing absence of knowledge concerning the proper range and scope of the visual function, and hence concerning the powers which the eyes ought to possess. Few things are more remarkable than the common want of information about all matters which relate to the use and functions of these important organs. In most other respects it may be said that the majority of parents have a fair notion of what ought to be the average powers and capabilities of children. They know, approximately at least, how far a boy of ten years old could reasonably be expected to walk, how high or how far he could jump, how fast he could run, what weight he could carry, what force he could exert. There is not one parent in 500 who has the smallest notion how large an object, say a capital letter, a boy ought to be able to see clearly at 100 feet away; or who could tell at what distance he ought to be able to see and describe the characters of an object of given magnitude. There is not one parent in 500 who can say off-hand whether his children possess natural acuteness of vision, or to whom the phrase "natural acuteness of vision" would convey any definite idea. There is not one parent in 500 who can tell whether his children possess natural colour vision, or who, if the inquiry were suggested to him, would know how to discover the truth. Mr. Francis Galton has lately pointed out, with great force and lucidity, that one of the most important duties of man, at the present stage of his development, is to regulate the progress of the evolution of his race; and one consequence of want of knowledge about vision is that the evolution of the eye has been left to be the sport of accident, or that it has even been injuriously affected by many of the circumstances incidental to civilisation. Into the operation of these circumstances it is now time to inquire, and for this purpose it is necessary to cast a glance at the structure upon which they act.

The general type of the eye of vertebrata is that it is a moveable organ, containing a lens which forms a reduced inverted image of external objects, and a layer of nervous tissue, called the retina, on which this inverted image is received, and on which it produces an impression which becomes the subject of consciousness. The whole apparatus much resembles the camera of a photographer. In birds and reptiles the eye is more or less tubular or cylindrical, while in mammalia it is approximately spherical, and the diagram on the wall gives a sectional view of it as it exists in man. I need not direct your attention to its subsidiary parts, but only to the lens, the retina, and to the shape and size of the eyeball as a whole. The lens and the eyeball should bear such proportion to each other that the focus of the lens for parallel rays of light, such as proceed from distant objects, should fall precisely upon the retina. It is manifest that this proportion may be departed from in two different directions; and that, if we assume the focal length of the lens to be invariable, the eyeball may be too deep, in which case the retina is too far from the lens, and the eye is short-sighted; or it may be too shallow, in which case the retina is too near the lens, and the eye is said to be flat, or hypermetropic. The retina—again discarding subsidiary parts of its structure—may be described as an assemblage of nerve fibres, the ends of which are directed towards the lens, so that, when we look at them through the lens, they form a sort of mosaic on which the image formed by the lens is received. This mosaic is composed of two elements, that is, of the terminations of two different kinds of fibres, which are called respectively rods and cones. The next diagram on the wall exhibits these two structures as they are seen in a section of the retina, and these show the arrangement of the mosaic on different parts of the retinal surface. In the human eye the functional centre of the retina is depressed below the general level, and from this circumstance is called the central depression, or, from being faintly tinged with yellow, the yellow spot. The region of the yellow spot is entirely occupied by cones. In the region around it, each cone is surrounded by a single circle of rods. In the rest of the retina, each cone is surrounded by several circles of rods, and these differences of structure indicate corresponding differences of function. The cones are more sensitive than the rods, both to light and to colour; and hence the acuteness of human vision is at its maximum in the yellow spot, is less around the yellow spot, and is least in the remaining portions of the retina. When we look at a moderately extended surface, we only see acutely that portion of it of which the image falls upon the yellow spot, and we see obscurely the portions of which the images fall upon the surrounding

portions of the retina. As a matter of ordinary proportion, the image of the nail of the fore-finger, when the hand is held out at arm's length, about covers the yellow spot, and thus about expresses the amount of surface which can be seen acutely without movement of the eye. I have here an instrument called a perimeter, which is used for measuring the lateral extent and acuteness of vision. If the eye is twelve inches distant from this central fixing point, is steadily directed to it, and is not permitted to swerve from it, this white object will indeed be seen as something white, even when its image falls upon quite an external part of the retina, but its precise shape and character will not be recognised until it comes within about two inches of the fixing point, and a letter printed upon it, of such a size as to be legible at ten feet when directly looked at, will not be legible until it comes within one inch of the fixing point. By means of the same instrument, we find that colours are only distinguishable near the central parts of the retina; and, from these and other reasons, we infer that the cones are the sole organs of the colour sense, and that their powers of general perception are much in excess of those of the rods.

In order that a retinal image may be perceived, and may excite consciousness, it must be of a certain magnitude; and the magnitude of the image depends partly upon the magnitude of the object, and partly upon its distance. The eye is so constructed that, in the formation of the inverted image, the waves of light proceeding from the object overcross at a point just behind the lens, and proceed from thence to the retina. Assume the line A B, in Fig. 1, to represent a vertical flagstaff, and C to be an eye directed towards it. The height of the image upon the retina would be the distance between the points of impact of two straight lines, A *a*, and B *b*, which would proceed from the extre-

Fig. 1.



mities of the flagstaff, would overcross at the point C, and would impinge upon the retina at *a* and *b*. The angle, A C B, or the equal angle, *a* C *b*, is called the visual angle, and measures the height of the retinal image. The diagram will show that if there were a smaller flagstaff, A′ B′, nearer to the eye than the original one, this smaller flagstaff, by being nearer, would be seen under the same visual angle as the larger and more distant one, and would cast upon the retina an image of the same magnitude. In the same way, if there were a second flagstaff, D E, the same size as A B, but nearer to the eye, it would be seen under the large visual angle, D C E, and would form the larger retinal image, *d e*. Other things being equal, the nearer the object, the larger will be its retinal image.

There are many reasons for believing that, in order to render an object visible, its image upon the retina must be large enough fairly to occupy the surface of one element of the mosaic on which the image is received, the surface of one rod or of one cone. If this be so, it follows that diminished size and increased number of the rods and cones would be followed by increased power of seeing small objects.

A retinal image is rendered visible by two qualities: first, by the variations in the amount of light going to form its different parts; secondly, by the similar variations in respect of colour. We know that individuals present great differences in the acuteness of their colour-sense, and we can easily satisfy ourselves of the existence of differences of sensibility to variations in the absolute amount of light. An eye that is very sensitive to light will see form with a less degree of illumination than another; and the uses of acute colour-sense are obvious. A colour-blind person, in a dim light, would scarcely see an English soldier, even when near at hand, if he were standing against a laurel-hedge, while a colour-seeing person would discern the spot

of scarlet against the green, even at a distance from which the outlines of the figure were unrecognisable.

I recur for a moment to the statement that the eye, in all its parts, has been developed out of skin tissue; and while the human race has only succeeded in developing the organ which I have described, other creatures' possessed of much better vision than ourselves, have developed an organ of corresponding superiority. The opportunities of obtaining perfectly fresh and healthy eyes for microscopic examination have been very limited, and less is known about their comparative anatomy than we could desire. But, in a general way, it may be said that the retinæ of birds contain a much larger proportion of cones than those of men; and that, not only in birds, but also in reptiles, the cones are provided with coloured globules, of various colours, which are, there can be no doubt, instruments of an acute colour-sense. Both birds and reptiles feed largely upon insects which closely resemble in colour the surroundings which they frequent; and the wonderfully acute vision of desert vultures, so often described by travellers, must, almost certainly, be ascribed to the acuteness of their colour-seeing. This diagram on the wall shows a single cone from the eye of a falcon, with the position of the coloured globule contained in it.

For a variety of purposes, we are obliged to fix a standard of what may be called normal vision; and it has been found, among the adult inhabitants of towns, that an object is not distinctly visible unless its parts are seen under a visual angle of one minute, and the object, as a whole, under a visual angle of five minutes. I have here some so-called test letters, which fulfil these conditions at stated distances, the largest at 40 feet, the second at 30 feet, the third at 20 feet, and the fourth at 10 feet. People who can read them at these distances are said to have normal vision, those who cannot are said to have sub-normal vision. I need hardly point out to you that the acuteness of vision of Humboldt's Indian, or of Arago's Tartar, was very much greater than this; and I see no reason why the acuteness which they attained should not be considered as normal to the human race. We cannot say whether their retinæ were better provided with cones than those of Europeans, or whether their cones were smaller as well as possibly more numerous, or were furnished with coloured globules. One thing only is certain, namely, that they and their ancestors had developed much better eyes than those which we see around us; and that other families of mankind, in favourable circumstances, may do the like.

The circumstances of civilisation, however, are exceedingly unfavourable. No one amongst us depends upon the possession of very acute eyesight for his safety from his enemies, or for his next meal; and, therefore, the stimulus to the improvement of vision which is afforded by direct and immediate usefulness is withdrawn. Many of the dwellers in towns scarcely ever see a distant object; and much of their work is done upon things quite close to them, from which they obtain large retinal images. They often work by very defective light, and are thus driven to resort to still closer approximation of the object, and it is by such approximation that the malformation of the eyes which produces short sight is mainly brought about. This malformation provides for its own increase in two different ways. As a point of structure, it is handed down to the posterity of those who suffer from it; and it is mechanically increased by the practice which it compels, that of turning the eyes inwards to combine upon a very near point.

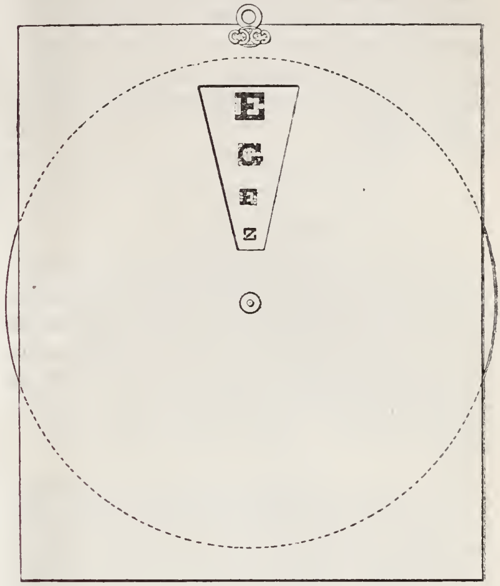
For the organs of living beings there is, as I have said already, no resting place; they must either advance or deteriorate, either continue in a course of improvement under the influence of evolution, or "throw back," as breeders say, to an earlier and less finished type under the influence of sluggish and imperfect use. Of deterioration we have an abundance of examples, and in two especially common ways. We have the malformation of short sight, which has come into existence within historic time, and into prevalence almost within living memory, and which now affects at least one-tenth of our population; and we have the malformation of flat-eye, which is plainly an involution, a return to an earlier and less perfect type, and which is attended, in the great majority of cases, by an acuteness of vision below even the humble standard with which our dwellers in towns are wont to satisfy themselves.

Is the evil a real one? No one who is engaged as I am can doubt that it is. I am frequently amazed at the ignorance of parents with regard to the very existence of visual defects in their children; and, still more frequently, at the tranquillity with which they will tell me that a child is short-sighted—a tranquility such as that with which they would

mention the colour of his hair. A short-sighted child, it must be remembered, is one whose accurate vision is confined within a circle of a foot, or a yard, or it may be of a few inches, from his eyes. Inclosed by this limited physical horizon, he often fails to develop the power of observation, he gains but little experience of life, and acquires but little knowledge of character or of events. He is blind to the expression of the human face, or to the larger beauties of nature or art; and his mind, even when intelligent and acute, is apt to display an acuteness which expends itself upon details, and exhibits but a restricted power of grasping principles. Moreover, the popular notions that short-sighted eyes are "strong" eyes, and that they improve with age, are entirely erroneous. The short-sighted person can frequently see a smaller object than another, the object being close to his eyes; but this does not depend upon greater acuteness of vision, but solely upon the fact that, being able to bring it very near, he sees it under a larger visual angle. This slight advantage, if such it be, is but a poor compensation for many disadvantages; and an eye which is short-sighted in a high degree, if not actually diseased, is at least always on the threshold of disease. The elongation of its shape has been arrived at by the gradual stretching out of its deeper hemisphere; and, in this stretching, the parts essential to sight can seldom escape injury. The flat eye, on the other hand, has no useful vision at any distance, except as a result of an alteration in the shape of its own lens, produced by muscular effort; and this effort, which increases in degree as the object approaches nearer, and which becomes more difficult of accomplishment every year, renders many possessors of flat eyes incapable of following occupations for which they would otherwise be eligible, and places a most serious impediment in the way of success in any sedentary occupation. Until Donders, about 1859, discovered the nature of this affection, and the extent to which it might be relieved by spectacles, those suffering from it were regarded as incurable, and were often advised to engage in pursuits such as Australian sheep-farming, in which the eyes might be employed almost exclusively on distant objects.

Is there any remedy for the conditions which I have attempted to describe? I think there is; and that it must be sought, first of all, in a recognition of the fact that good sight is an important point of physical excellence, which, like any other such point, should be assiduously cultivated. I would urge parents to procure such a testing instrument as this (Fig. 2), which is made by Mr. Baker, of 244, High

Fig. 2.



Holborn, and to ascertain, as soon as their children know the alphabet, whether they can decipher the letters at the proper distances. I would urge upon them, in the case of every child whose vision is subnormal, to ascertain the cause and nature of the defect, and to regulate not only the studies, but also, as far as possible, the future career, in accordance with it. I would urge upon all who have the control of schools, that the vision of every new pupil should be tested on admission, and that the tasks required should be controlled in accordance with its capabilities. I would urge that all lesson books for very young children be printed in large type, and that the children should be compelled to keep such books at a distance (the type in which we often see texts of Scripture printed to be hung up in railway waiting-rooms would be a good size for the purpose). I would urge that many of the school-books now in use should be abandoned; and that new editions should be prepared, in type of at least twice the size, and twice the legibility (the latter depending much upon the shape and design of the letters) of that which is now in use. Finally, I would urge upon all who are concerned in the organising of athletic sports and contests, that excellence of vision

should be highly esteemed in such competitions. I feel sure that, if public attention were once fairly directed to the question, if the eyes received as much attention as the muscles, and if an intelligent knowledge of what they ought to accomplish were diffused abroad, that our country, in the course of two or three generations, would be peopled by a race who might engage, if not without fear, yet certainly without disgrace, in a seeing contest with any other representatives of the human family.

DISCUSSION.

Mr. W. A. Frost thought it was a great pity that some plan could not be organised on a large scale to test the schools of London. It was unfortunate that the School Board did not see its way to accede to Mr. Carter's request, especially as an examination of one school showed how very wide spread was this evil, and how important it was to ascertain accurately its extent.

Mr. Gregory said he had given great attention to this subject during the whole of his professional life, and had seen for many years the gradual operation of this cause in a semi-urban district, where school teaching had been going on for a large number of years. He was quite sure that deterioration of eyesight amongst these children, in the country, had been progressive, though not perhaps to the same degree as in London; it had been going on from 1835 up to the present time, and every year he saw more and more disease in the eye, especially in the two directions Mr. Carter had mentioned, but there were also many cases of astigmatism. He believed that schools were conducted on a wrong plan; the senses were not educated, and children were injured by teaching them to read and write at too early an age, instead of teaching them to use their fingers, their eyes, and their ears. Amongst some of his patients and friends he had had the opportunity of seeing children trained in his own way, teaching them first to draw and to play the piano, and these children always outstripped their competitors when they went to school, though they had never learned to read and write until they were eight or nine. They picked up a good deal of information notwithstanding; by asking questions their minds were more open and free, and especially by learning to draw they learned to put things together, and obtained much better general ideas. When children were put to books, and allowed to sit in dark corners and read, their organs got blunted; they grew up peculiar, and often one-sided. The first step in education was how to use the fingers; everyone ought to be able to use their left hand as well as their right, but not one in a hundred could do so. In women's work they were obliged to use their left hands, and he thought they were more equally-minded than men on that account. A great deal depended on the care of the eyesight, and with regard to his own eyesight, he might say he was certainly fifteen or twenty years younger than most men of his age, though he had read a great deal, and at night, but he attributed this to having taken care of his eyes, and to having used them a great deal in the open air.

Mr. Carsten Holthouse said he was particularly interested in what had been said as to the distant visions of savages, but he should like to know if their eyes had been tested for minute and near objects. Eyesight, like the other senses, could be educated, and it was a question whether those who were accustomed to view objects at a great distance did not thereby become, to a certain extent, long-sighted, while those whose vision had a more limited range could not. For instance, seafaring men could generally espy a ship at a much greater distance than a landsman, but whether these people could equally well see small microscopical objects, such as scientific men, watchmakers, &c., had to observe, he was not sure.

Mr. Curtis said he could confirm, from his own experience, much which Mr. Carter had said; but most practising oculists would agree that parents were not quite so careless in this matter as they were formerly.

Mr. John Browning remarked that there were an immense number of people who were very short-sighted, and were quite aware of it, but whom nothing would induce to wear glasses. Within the last few years he had met with many who could not see any object an inch in diameter at three feet distance from their faces, and yet they would not use spectacles. The result of this must be disastrous; such people must confine their attention during the whole of their lives to objects which were within seven inches of their faces; and he had heard, within the last month, three ladies say they should not know their own husbands if they touched their shoulders in the street, unless they looked right into their faces.

Mr. H. Trueman Wood asked Mr. Carter if he did not think that individual training and education, as distinct from inherited faculty, had rather more influence in this matter than he had allowed for. It seemed to him that a certain amount of practice was required for any special sort of sight. A sailor would distinguish the rig of a ship at a much greater distance than a landsman of equally keen sight, because he knew what to look for. The same with a gamekeeper, or a forester; a gamekeeper could always see a hare sitting in her form, or mark down birds much farther off than a townsman. Perhaps the most

remarkable instance, however, was that of puddlers, who were in the habit of looking into a fiery furnace, and who could see objects in it when anybody not used to it would merely see a blaze of light. He remembered a case mentioned by Mr. Mathieu Williams, of a puddler being able to see the spots on the sun, when no one else could look at it at all without darkened glasses. As regards Mr. Browning's remarks upon the dislike some people had to using spectacles, there were two sides to that question; he himself should be only too glad to avail himself of the aid of glasses, if Mr. Browning or any one else could furnish him with some which were of any real advantage to him; but though he had about half-a-dozen pairs which he had tried at various times, he had never found any of sufficient use to him to be worth the trouble of carrying about.

Mr. M. S. S. DIPNALL said he had had some experience with regard to blindness, being secretary to the largest blind charity in the country; and he did not notice that Mr. Carter stated that this short-sightedness in youth eventuated in blindness in old age. His experience, extending over some years, led him to the conclusion that blindness had not increased. He believed vaccination had been a powerful agent in keeping down blindness and on the whole though; owing to the extension of manufactories, there were more accidents, and other causes of blindness, yet owing to improvement in treatment in ophthalmic institutions, there had not been any increase in fact. Those who received annuities from the charity he had referred to, must be upwards of sixty years of age, and the period of their affliction ranged over very various periods, some even from birth, but it was found that some even at eighty had only been blind a few years. Considering the number of occupations which were carried on at night by gas-light, such as Parliamentary reporting, newspaper printing, &c., he thought there never had been a time when the human eye was so much tried as it now was. Mr. Carter had not alluded to the volunteers, but it seemed to him in their case the eye must be trained to very great perfection, or such remarkable scores would not be made. He had been struck last autumn, when travelling on the Rhine, with the large number of Germans who wore glasses.

Mr. J. J. EASTICK inquired if persons who suffered from short sight had the same power of adjusting the focal length of their eyes as those having normal sight?

The CHAIRMAN said the keenness of sight possessed by savages was a fact beyond all question. Mr. Francis Cobb, who had just left, told him that a few years ago in South Africa, when talking to some Zulus who were in his employ, he saw a small speck on the distant landscape, and asked them what it was. They said it was the missionary and his wife, that the lady was on horseback, and the man was walking by her side. With a pair of binocular glasses he could discern that one was a lady, but could not see that she was on horseback, and yet these men could not only do that, but recognised the individuals. He thought there could be no longer any doubt that in civilised man the eyesight had degenerated, rather than that the savage possessed a superior power. Mr. Carter had not perhaps so fully dealt in this paper as in his letter to the *Times*, with the point that there was inherited degeneration wherever you had faulty sight. There could be no doubt that from generation to generation flat eyes, weak sight, astigmatism, and various other defects, would be handed down from father to son, and that was really at the bottom of the evolutionary degeneration to which attention had been drawn. Another important consideration was that now many people lived so much amongst books, and bookwork was clearly one of those things in civilisation which tended to produce this degeneration. There was a very broad distinction between blindness and mere imperfection of sight, for the former was more prevalent amongst the savages in South Africa than amongst any other people he knew, notwithstanding their wonderful keenness of sight. Everyone must sympathise with Mr. Carter in regard to the curious reply he received from the School Board when he applied for leave to obtain further information on this important subject, and he could only account for it on the supposition that civilisation might also bring about cerebral degeneration as well as defective eyesight. In conclusion, he would draw attention to the Lettsomian lectures delivered by Mr. Carter before the Medical Society of London, and recently published, which, though technical, were so admirably lucid that anyone could follow the argument. One great point insisted on therein, was that owing to recent advances in surgery, it was no longer necessary for persons suffering from cataract to wait for years, getting more and more blind, as was formerly the case, before the cataract could be removed, because it was often possible to give relief at once.

Mr. CARTER, in reply to the first question which had been put, said the acuteness of distant vision must depend on the power of seeing a very small retinal image; and the power of seeing an equivalent object near at hand depended on the power of altering the adjustment, the accommodation, as it was called, of the eye; and this was quite independent o the seeing faculty when the eye was at rest. This power of adjustment diminished as life progressed; it attained its maximum at the age of eleven or twelve, and gradually diminished until, at the age of forty-five, it generally reached such a point that one could not read a book at a less distance than about four feet, and tried to get a light between the book and the eyes; or, as Dr. Kitchener said, who wrote

before gas and lamps were much in use, one blessed the memory of the man who invented snuffers. The power of seeing a small retinal image would involve the power of seeing it at any distance as long as the function of accommodation remained unimpaired. There were certain test objects employed which consisted of a number of dots put together, the acuteness of vision being tested by calling on the person to count the dots at a given distance. A person who could count large dots farther away than another, would probably be able to count smaller ones farther away also, assuming the power of accommodation were the same in both. There was no necessary connection between short sight and blindness, beyond that mentioned already, that a very short-sighted eye was on the threshold of disease, and a larger proportion of such eyes than of normal eyes would, therefore, probably lose vision. With regard to the number of cases of blindness, his object had been to keep clear of all question of disease from which blindness usually resulted. There could be no doubt that the keeping of small-pox in check had done a great deal to prevent blindness; but a very common cause of blindness, which accounted for fully one-third of all the cases, was purulent ophthalmia, which was apt to attack young infants during the first three or four days of life. Everyone should know that this disease, which was extremely likely to destroy the eyes, was curable with almost absolute certainty, if attended to in time. So much was this the case, that a committee had lately been formed, of the Ophthalmological Society, with a view of urging on the Government to supply registrars of births with notices to give parents who came to register the births of children, stating the importance of this affection, and the necessity for its being promptly treated when it occurred. In Ireland this had already been done, and although such a notice might sometimes come too late for the child actually registered, it would not be too late for the next. With regard to the unwillingness of short-sighted persons to wear spectacles, he would mention an argument he always used to the mothers of young ladies, which he found extremely potent. He said, unless you make the girl grow up in spectacles, in the first place she will never see the expressions of the human face; next, she will never obtain any power of estimating character, and then she will make a foolish marriage. He generally found that even the most prejudiced were convinced by that argument. He had not been speaking of blindness, but merely of the structural degeneration which came from disuse, and he could give a forcible illustration of that amongst the lower animals. The cones were the most highly organised of the retinal elements, and in birds these cones were much more numerous than in man; but in the bat, and some other nocturnal animals, there were no cones at all. The bat was thought to depend for catching its prey almost entirely on the acuteness of its hearing, and its ears were very large, and highly developed; its eyes were presumably little used, and this was the result—retrogression, involution, and a diminution of the proper development of the organ. With regard to the respective influence of personal training and descent, it was extremely difficult to allot to each its proper share in the general result. In the great majority of cases the forester was a son of a forester, and so on; and one had very often, both in diminished and in exalted acuteness of vision, the influence both of inheritance and of personal training. Constant practice, no doubt, might do a great deal to develop acuteness of sight; but inheritance from acutely sighted parents was equally valuable, and it would be exceedingly difficult in any given case to determine how much was due to one cause and how much to the other. The power of accommodation in short-sighted eyes was obviously deficient, because there was no need to exercise the function. Assuming a person had short sight, so that his distance point was ten inches, he could read small print at that distance without any accommodation at all, and as he would seldom want to bring any object nearer, he would have no occasion to exercise the power of adjustment. Therefore, in cases where the far point was fifteen inches, or under, the accommodation was apt to be extremely defective. In his communication to the *Times*, he had referred pointedly to the volunteers, singling them out as persons who ought to take the lead in that which he had now said with regard to all who were concerned with athletic sports. He also said that if volunteers would devote a little attention to this subject, they might very soon reduce the size of the bullseyes on their targets. With regard to the concluding remarks of the Chairman, he would only say that the subject was a strictly professional one, which it would not have occurred to him to introduce, though, as Dr. Mann had said, he had advanced the opinion that by the adoption of modern surgical improvements those suffering from cataract might frequently be relieved at an earlier period than was formerly practicable.

The CHAIRMAN then proposed a vote of thanks to Mr. Brudenell Carter, which was carried unanimously, and the meeting adjourned.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

Considerable as were the additions made last year, for the purposes of the Health Exhibition, to the buildings which had served in the previous year for the Fisheries Exhibition, it has been found necessary

to increase these buildings yet further, in order to afford room for the articles which have been selected from a large number of applications for the Exhibition of Inventions. Readers of the *Journal* will be interested by a short account of these additions, and also by a sketch of the arrangements which have been adopted for the exhibits. It will, of course, be understood that these are still liable to considerable modification, though it is unlikely that much alteration will be made as regards the disposition of the groups in the various galleries of the building. The chief addition consists in the erection of two additional galleries, one on the north side and one on the south side of the old South Gallery—that is to say, the gallery at the south end of the building, to which admission was gained direct from the principal entrance in Exhibition-road. This building will in future consist, therefore, of three galleries of almost equal span, of which the old South Gallery will be the centre.

The dining-rooms have been removed from their position at the eastern end of the gallery to a similar place at the western end, near the goods entrance in Queen's-gate. Their former site will be occupied by the new South Court. The new North Court occupies the ground covered last year by the galleries containing the bakeries, the meteorological exhibits, the anthropometrical laboratory, &c. The gallery known as the West Annexe, which ran parallel with the West Gallery containing the machinery in motion last year, has been enlarged by the covering in of the space formerly existing between it and the West Gallery. On the opposite side of the Exhibition an additional space has been gained by covering in the space between the Arcade and the East Gallery running parallel with it. These form the principal alterations in the buildings. In the ground to the south of the south galleries it is proposed to lay down a railway, on which experimental tram-cars can be shown in motion.

Turning now to the arrangement of the groups. Coming from the main entrance and entering the south gallery, the visitor will find the objects belonging to Group XXV., Fire-arms, Military Weapons, &c.; next to this comes Group V., Railway Plant; and next to this again, at the western end of the gallery, Group IV., Prime Movers. The new South Court, which, as above stated, occupies the site of the dining-rooms in the Health Exhibition, is devoted to Group I., Agriculture. In the new North Court will be found in order from east to west Group III., Engineering Construction; Group XII., Elements of Machines; and Group II., Mining. In the South Central Gallery, which runs from east to west on the north side of Old London and of the Prince's Pavilion, will be found in order from east to west, Groups XIV., Applied Chemistry and Physics; XXVIII., Philosophical Instruments; XXIX., Photography; XXVII., Clocks and Watches; XIX., Jewellery; XXII., Furniture. The two galleries on the east and the west of the Central Avenue will be allotted to foreign countries, and the arrangement of these galleries is consequently not yet complete. It is proposed to erect in the north-east corner of the Eastern Gallery a concert-room, which may be employed for practical trials of musical instruments. The Central Gallery, in which last year the exhibits from the Art Schools were placed, with the annexes to the main gallery, will all be given up to Division II., Music. The larger organs will be placed at the ends of the gallery, and it is also proposed that others of the organs sent in for exhibition should be arranged in different parts of the building, so that rehearsals on them may go on at differeut times without interference. Coming back to the main entrance, and turning up northward through the Eastern Arcade, the following groups will be found:—XIII., Electricity; XV., Gas; XVI., Fuel; XXX., Educational Apparatus; and Group VIII., Aeronautics, will be placed in the new space between the arcade and the Eastern Gallery. In the Eastern Gallery is Group XXVI., Paper and Printing; while the northern end of the gallery will be occupied as last year by a Chinese collection. The Eastern Annexe, a smaller building to the west of the East Gallery, is given up to Food, &c. The Chinese dining-room will remain the same as last year. The quadrant on each side of the conservatory will be divided amongst the following groups, still taking them, as before, in order, from east to west:—XXXI., Toys, &c.; XVIII., Clothing; XX., Leather: these being on the eastern side; and on the western side:—XXI., Indiarubber; XXIII., Pottery and Glass; XXIV., Cutlery, &c. Refreshment pavilions will be placed, as last year, at the south end of each quadrant.

Considering now the buildings on the western side of the Exhibition, and taking them from north to south, in the order which would be followed by a visitor walking round the Exhibition, and having reached the south end of the West Quadrant, Group IX., Textile Fabrics, will be found in the northern part of the West Gallery, and of the West Arcade. The southern portion of the West Arcade will be occupied, as in the two previous Exhibitions, by the Aquarium. The southern portion of the West Gallery, that is, the machinery in motion gallery of the Health Exhibition, will be devoted to Group X., Machine Tools, &c. In the enlarged western annexe, Group XI., Hydraulic Machines, Weighing Machines, &c., will be found. A portion of this group also spreads over into the Queen's-gate annexe, the new building which was erected last year, and the greater part of which was occupied by the Belgian Court. The rest of the building is given up to Groups VI., Common Road Carriages, amongst which will be found Bicycles and Tricycles; and Group VII., Naval Architecture. The loan collection of musical instruments, &c., which it is proposed to form, will be placed in some part of the galleries of the Royal Albert Hall.

The subway from the South Kensington Railway Station to the Exhibition Buildings is making rapid progress. The contractors have promised that it shall be finished in time for the next season, so that during the coming summer it may be practicable for visitors to go from any station on the line right into the Exhibition Buildings without reference to weather. This will certainly lessen to some extent the inconvenience experienced by the residents in the neighbourhood from the great streams of people thronging up the roadway. The subway will follow the road till it approaches the post-office, will then strike across a corner of the ground attached to the Natural History Museum, and will enter the Exhibition on the southern side of the entrance Hall, not far from the site of last year's first-class refreshment-rooms. Thus the main stream of passengers going by rail will have an entrance separate from that in the Exhibition-road. A branch will also lead to the South Kensington Museum. The passage, as at present planned, will be eighteen feet wide and eleven feet high, and thirteen or fourteen hundred feet long.

PUBLIC INSTRUCTION IN SPAIN.

Her Majesty's Secretary of Legation at Madrid says that Spain is divided, for educational purposes, into the following university districts:—Madrid, Barcelona, Valencia, Seville, Granada, Valladolid, Santiago, Saragossa, Salamanca, and Oviedo, and the rectors of these ten universities are the connecting links between the educational systems of their respective districts and the central government of Madrid. It is the duty of a rector, independently of his more immediate concern with the university of which he is the chief, to see that all the schools and colleges within his district are managed as the law directs; to report on their condition to the director-general, and to give publicity to the decrees of the executive relating to education. He presides over a consultative university council, composed of the deans of faculties, directors of superior schools, and other nominees of the Government. Each university district is provided with a Government inspector, who is required to visit every educational establishment within his district, with the exception of the primary schools, at least once every year. The salary is £100 a year, besides travelling expenses. A university district includes several provinces, at the capital of each of which the central governor is represented officially by the civil governor of the province, who is chairman of a provincial school board, consisting of a provincial deputy, a member of the municipality, the school inspector of the province, an ecclesiastical nominee of the bishop, and several fathers of families. These members of the board are all approved by the Government, who choose most of them from lists submitted by the civil governor. The different kinds of instruction obtainable are classified under three heads—primary, secondary, and superior. Primary schools are placed under the special charge of the municipalities, every town of 500 inhabitants being obliged to maintain at least two such schools, besides an equal number of schools for girls. An additional primary school, private or public, was imposed by law for every additional 2,000 inhabitants. Villages of less than 500 inhabitants combine to form school districts. Parents or guardians are called upon to send their children or wards, between the ages of six and nine years, to a public primary school, unless proper provision is made for their education in a private establishment or at home. Defaulters may, at first, be admonished by the municipal authorities, and finally punished, if necessary, by fines ranging from fivepence to four shillings and fivepence. It is said, however, that the articles relating to this part of the law have always remained a dead letter, and no parent is compelled, or even asked, to send his children to school. Public primary schools are paid for by the municipalities, if the amounts they obtain from endowments and from pupils are insufficient for their maintenance. Public primary instruction is free of all charge for all children whose parents or guardians are certified by the parish priest and alcalde to be unable to pay, and in the year, 1880, it appeared that out of a total of 1,442,577 children on the books of the public primary schools, only 333,545 paid anything for their instruction. The fees to be paid in the public primary schools are determined by the municipal boards of primary instruction, snbject to the sanction of the provincial school board. According to statistical returns which have been prepared on this subject, it appears that for the period comprised between 1870 and 1880 the average annual charge on the solvent class of pupils is approximately 4s. 9d. per head, equal to about 1·1d. a week, and au annual sum of about £86,000 for the whole of Spain is derived from these fees. Instruction in the Roman Catholic religion is compulsory only in the primary schools. The course of instruction in the primary schools is intended as a preparation for the *Institutos* or secondary schools. There must be at least one public school of this classs in every province, and the expense is borne by the provinces, except in the case of Madrid, where there are two *Institutos* supported by the central government. The fees paid by the students are sufficient to cover the greater part of the cost of these establishments, several thousand names being inscribed on the books of the larger *Institutos*. Students are admitted to the ten universities of Spain after gaining the degree of "Bachelor," which is conferred at the end of the course of study in one of the institutes. The university career is divided into two courses, the first of which terminates with the degree of "Licentiate," and the second with the degree of "Doctor." There are at present on the books of the Spanish universities, 15,732 students, 6,659 of whom are studying

medicine; 5,917, law; 1,915, pharmacy; 580, science; and 561, philosophy and letters. The annual cost of the universities to the State is about £130,000, but the burden to the State is in reality much lighter, as a large sum is derived annually from the various university fees. A statistical return has lately been published by the Director-General of Instruction, relating to the period comprised between the years 1871 and 1880. From this it appears that at the end of 1880 there were in Spain 23,132 public and 6,696 private schools, the greater number of the former being in the province of Leon, and the latter in Barcelona.

Notes on Books.

Turning and Mechanical Manipulation. By J. J. Holtzapffel. Vol. V. London: Holtzapffel. 1884.

The fifth volume of Mr. J. J. Holtzapffel's continuation of his father's well-known work upon turning has now been published. It will be remembered that Mr. Charles Holtzapffel only completed the first three introductory volumes, the fourth volume, which appeared in 1879, and dealt with hand or simple turning, being due to the younger Holtzapffel. The book is to be finished in six volumes, the subject of the sixth volume being the principles and practice of amateur mechanical engineering. The first part of the work, after a short historical introduction, deals generally with the tools used for ornamental turning-materials, and methods of chucking. The next two chapters are devoted to an account of the slide rest, from its simple ancient form down to the complicated apparatus used in modern ornamental lathes. Overhead motions, new and old, are described at the same time. Cutting frames, drills, &c., in their simpler and more complex forms, are described in the next three chapters. Chapter VII. is devoted to the eccentric and oval chuck. Chapter VIII. deals with the spherical chuck, the rectilinear chuck, and other similar chucks, while the ninth chapter shows the use of the various ornamental chucks in combination. The next subjects dealt with are compound eccentric turning and spiral turning; while the volume concludes with a chapter on the spherical rest. The book is very fully illustrated with woodcuts of tools, illustrations of geometric turning, printed in the usual way from blocks cut in the lathe, and autotype reproductions of photographs of specimens of ornamental turning, some of them of a very complicated nature.

The Year-Book of Photography, 1885. Edited by T. Bolas. London: Piper and Carter, 1885.

The special feature of this well-known photographic annual for the current year is that it is very fully illustrated with specimens of the various processes by which printing blocks are produced from photographic negatives. Amongst the methods thus exemplified may be mentioned those connected with the names of Meissenbach, Ives, and Annan. The frontispiece is a portrait of the late Mr. H. Baden Pritchard, who was for many years the editor of the *Year-Book*, as well as of the *Photographic News*, the journal with which the annual is connected. This picture was produced by Messrs. Annan, of Glasgow, from a photograph taken in Algiers not long before Mr. Pritchard's death. Another of the illustrations serves as a specimen at once of Ives's process, and of the results which can be obtained by what are known as "isochromatic plates," plates, that is to say, in which the relative effect of the rays at the red end of the spectrum is greater than with the plates ordinarily employed. The result is that the various natural colours are translated in a scale of light and shade which corresponds fairly well with the appearance presented to the eye. It is well known that in an ordinary photographic print blues come out lighter, and reds come out darker than appears natural. In a photograph taken by means of one of these plates this effect is lessened, and we get a result more nearly resembling what we see. In the example given, a rather violently coloured lithograph was selected as the copy, and two photographs of it are shown, one taken by an ordinary, and one by an isochromatic plate. The book forms the usual record of photographic progress during the year, and contains a large amount of information likely to be useful or interesting to photographers.

Persian for Travellers. By Alexander Finn, H.B.M. Consul at Resht. London: Trubner and Co., 1885.

This work, which is by a member of the Society of Arts, is intended for travellers in Persia who are entirely, or almost, entirely ignorant of Persian. It is simply a vocabulary: the English word is followed by the Persian equivalent, which, besides appearing in Persian characters, is given in English letters. In doing this, Mr. Finn says "No learned attempt has here been made to phoneticize the words or always to represent the same Persian by the same English letters; each word has been written down as seems to be necessary for any Englishman to be able to pronounce it intelligibly to Persian ears at first sight and without hesitation." There is a very short introduction, giving a brief sketch of Persian grammar.

Stanford's Compendium of Geography and Travel, based on Hellwald's "Die Erd und ihre Völker."

North America. Edited and enlarged by Prof. F. V. Hayden, and Prof. A. R. C. Selwyn, F.R.S. London: Stanford, 1883.

AUSTRALASIA. Edited and extended by Alfred R. Wallace, with Ethnological Appendix by A. H. H. Keane. Fourth edition. London: Stanford, 1884.

ASIA. With Ethnological Appendix by A. H. Keane; edited by Sir Richard Temple, Bart., G.C.S.I. London: Stanford, 1882.

EUROPE. By F. W. Rudler and G. G. Chisholm; edited by Sir A. C. Ramsay, F.R.S.; with Ethnological Appendix by A. H. Keane. London: Stanford, 1885.

These works on the great divisions of the world are all founded on Dr. Hellwald's great book, "The Earth and its Peoples;" but in most cases they have been almost entirely rewritten, and this is especially the case with the volume on Australasia. Each volume contains a physical and an historical description of the different countries which form the continent to which the volume is devoted. An appendix containing an account of the ethnology and philology of the different races, by Professsor Keane, is also added. The volumes are fully illustrated with physical and geographical maps of the various districts, as well as woodcuts representing the cities, country, and inhabitants. They complete the series of compendiums of geography already published by Mr. Stanford.

NATURE'S HYGIENE: A Systematic Manual o Natural Hygiene. By C. T. Kingzett, F.I.C., F.C.S. Second edition. London: Baillire, Tindall, and Cox, 1884.

This is the second edition of a book already noticed in this *Journal* (vol. xxvii. p. 636.) The great part has been rewritten, and chapters on water supply, sewage, infectious diseases, and the treatment of the sick, have been added. The first part deals with the general principles of natural hygiene, and the second part with the chemistry and hygiene of the eucalyptus and the pine.

THE ART OF LEATHER MANUFACTURE: being a practical Handbook in which the Operations of Tanning, Currying, and Leather Dressing are fully described. By Alexander Watt. London: Crosby Lockwood and Co., 1885.

The author states, in his preface, that he was induced to produce this handbook by finding that although numerous books on the various branches of the leather trade had been published in France, Germany, and Austria, no English work on the subject existed. The chemical theory of the tanning process is explained, and a full description of the various modes of treating hides and skins is given. Special chapters are devoted to the various tanning processes in use in this country and abroad. Dyeing, currying, and tanning, are described; and special attention is paid to the machinery used in leather manufacture. At the end of the book are chapters on parchment, vellum, and shagreen, glue boiling, and the utilisation of tanners' waste. The volume is fully illustrated.

General Notes.

TECHNICAL SCHOOLS IN ITALY.—At a congress of Italian silk manufacturers, recently held at Turin, resolutions were adopted, calling upon the Government to advance the money required for bringing spinning and weaving schools to as high a standard of development as possible. It was likewise suggested that the amount of Government taxes should be reduced in the case of the silk industry, when losses of an important character had taken place in any year; and likewise that the valuation of manufacturing premises and machinery for taxation should be conducted on a more equitable principle. A proposal was made for a Government prize competition, as the best means of obtaining plans for the utilisation of water power by spinning establishments.

PARIS INTERNATIONAL EXHIBITION, 1885.—It is the intention of the Minister of Commerce to have exhibited a collection of teaching material and specimens of results from French schools. The educational section in Group V. (Classes 38 to 44), will comprise plans, models, &c., of schools and other institutions; teaching appliances, gymnastics, military exercises and equipments, &c.; printing and books; stationery, office furniture; photography, musical instruments. In the scientific annexe will be included geology, ethnography, hygienic discoveries, instruments and apparatus for medicine; surgery; astronomy; geography; weights and measures, and moneys of different nations. The artistic annexe is to comprise paintings, sculpture, architectural models and designs, reproductions of ancient and modern monuments, paintings on enamel, porcelain, medals, &c., and industrial arts.

GROSVENOR GALLERY.—The Winter Exhibition this year at the Grosvenor Gallery is chiefly devoted to the works of Gainsborough, and it contains a larger number and more representative collection of his portraits than have previously been brought together for exhibition. There are in all 216 pictures, and this number includes a few landscapes. On the right hand of the first room, as the visitor enters the gallery, is the portrait of Jacob, Viscount Folkestone, first President of the Society of Arts, which has been lent by the Council of the Society. The picture was painted in 1776 as a companion to the portrait, by Reynolds, of Lord Romney, the second President of the Society. As Lord Folkestone had died in 1761 it was necessary to use an existing portrait for the likeness. The second Lord Folkestone lent a portrait of his father, by Hudson, for the purpose. One hundred guineas was paid to Gainsborough, which, in his own words, was "the price he usually charged for a full length picture." When the portrait came into the possession of the Society, it was resolved that "the thanks of the Society be given to Mr. Gains-

borough for his excellent execution of the picture of Lord Folkestone, and he be informed that the Society are highly satisfied with his masterly performance."

German Cotton Imports.—The German Minister of Commerce has lately been collecting information as to the proportions in which cotton manufacturers derive their supplies of the raw material direct from the countries of production. According to the *Wochenschrift fur Spinnerei und Weberei*, only about one-fourth of the entire consumption is purchased in Europe, the remainder being imported direct by the manufacturers, or bought to arrive while floating. Attention has been drawn to the development of this class of trade, which may be looked for when direct steam communiation has been thoroughly organised between the East Indies and the ports of Bremen and Hamburg.

Hungarian National Exhibition.—A general National Exhibition for the kingdom of Hungary will be opened on May 1st next, and will be closed on October 15th. In connection with this there will be found an international section, for motors, working machines and tools for artisans, as well as for agricultural machines of the latest and most improved constructions, and also for important patented inventions and improvements. There will also be an international exhibition of seeds, cattle food, and manure; and an international temporary exhibition of living animals. The latter will be arranged as follows:—Poultry and rabbits, from 5th to 10th May; dogs, from 5th to 10th May; fat cattle and sheep, from 17th to 24th May; breeding sheep, from 20th to 30th May; bees, from 20th to 30th August; breeding swine, from 1st to 8th September; fat swine, from 1st to 18th September; horses, from 5th to 10th October. It is announced that special attention will be devoted to the exhibition of motors, small machinery for home industries, tools and implements, &c. Hungary being chiefly an agricultural country, it is stated that this especial feature of the Exhibition must, to become successful and lead to the lasting benefit of the people, be of an international character, and the committee appointed to carry out the object rely upon the general participation of foreign exhibitors, who will make themselves and the articles in which they deal better known in a large and improving country. The interest and help of the manufacturers of the United Kingdom is particularly solicited. Mr. F. Ráth has been appointed Honorary Commissioner for the Exhibition. His address is 18, Queen Victoria-street, E.C.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at Eight o'clock:—

February 4.—"Education in Industrial Art." By Charles G. Leland. Earl Brownlow will preside.

February 11.—"Report of the Royal Commission on Metropolitan Sewage." By Captain Douglas Galton, C.B., F.R.S. Sir Frederick Abel, C.B., D.C.L., Chairman of Council, will preside.

February 18.—"Malt-making." By H. Stopes.

February 25.—"Past and Present Methods of Supplying Steam Boilers with Water." By W. D. Scott Moncrieff, M.Inst.C.E.

Indian Section.

Friday evenings at Eight o'clock.

February 20.—"The Teak Forests of India and the East, and our British Imports of Teak." By P. L. Simmonds. Colonel Michael, C.S.I., will preside.

March 6.—"The Trade between India and the East Coast of Africa." By Frederic Holmwood, British Consul at Zanzibar.

April 17.—"The Parsis and the Trade of Western India." By Jehangeer Dosabhoy Framjee.

May 8.—"The Ancient and Modern Methods of Treating Epidemics of Small-pox in India." By Robert Pringle, late Sanitary Department H.M. Bengal Army.

Foreign and Colonial Section.

Tuesday evenings at Eight o'clock.

February 24.—"The Spanish Gold-fields and the Mines of Rio Sil." By William Sowerby.

March 17.—"The Congo and the Conference, in reference to Commercial Geography." By Commander Cameron, R.N., C.B.

March 31.—"Kiliman'jaro and the Surrounding District of Equatorial Africa." By H. H. Johnston.

Applied Chemistry and Physics Section.

Thursday evenings at Eight o'clock.

February 12.—"Production of Ammonia from the Nitrogen of Minerals." By George Beilby.

February 26.—"Tempered Glass." By Dr. Frederick Siemens.

March 12.—"Recent Improvements in Photographic Development." By W. K. Burton.

April 23.—"The Chemistry of Ensilage." By Frederick J. Lloydd.

The dates given above are subject to alteration.

Cantor Lectures.

Monday Evenings at Eight o'clock.

The Third Course will be on "The Distribution of Electricity." By Professor George Forbes, M.A., F.R.S.E.

Lecture I. Feb. 2. — General statement of the problem.—Electrical distribution for lighting supply from a central station. — Success of electric lighting largely dependent on economy of distribution.—Comparison with gas.—Limits to the smallness of conductors.—Waste of energy in mains. —Undue heating of mains.—Fall of potential.—Methods proposed for laying mains (1) for low potential; (2) for high potential.—Testing mains.

LECTURE II. Feb. 9.—Five systems of distribution: (1) multiple arc; (2) series; (3) multiple arc series; (4) accumulators; (5) secondary generators. —Systems for multiple arc distribution: (1) parallel line; (2) parallel reversed line; (3) tree mains; (4) independent wire mains; (5) network mains.—Importance of using high potential lamps.—Massive mains *versus* independent wire mains.—Considerations as to size of districts.

LECTURE III. Feb. 16.—Series mains.—Multiple arc series.—Methods which have been used.—Modifications proposed.—Economy of this system.—Supposed danger of high potentials.—Three wire system.—Accumulators used in two ways: (1) charge and discharge in series; (2) charge in series, discharge separately.—Secondary generators.—Example of central station lighting now accomplished.—The problem an engineering problem with all the data for calculation.—Conclusion.

HOWARD LECTURES.

Thursday evenings at Eight o'clock:—

The sixth lecture of the Special Course delivered under the Howard Trust, on "The Conversion of Heat into Useful Work." By W. ANDERSON, M.Inst.C.E.

LECTURE VI. Feb. 5.—Hot Air-engines; Nature of their Action, Mechanical details, Limits of Efficiency. Compressed Air Refrigerating Machines. The Steam-engine, Non-condensing, Condensing, and Compound; Nature of its Action, Mechanical details, Limits of Efficiency, Results actually obtained.

ADMISSION TO MEETINGS.

Members have the right of attending all the Society's meetings and lectures. Special tickets are required for the Juvenile Lectures. Every member can admit *two* friends to the Ordinary and Lectural Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the members, but admission can also be obtained on the personal introduction of a member.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 2...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. George Forbes, "The Distribution of Electricity." (Lecture I.)

Farmers' Club, Inns of Court Hotel, Holborn, W.C., 4 p.m. Discussion on Mr. James Howard's paper, "Farm Rents: Past, Present, and Future."

Engineers, Westminster Town Hall, S.W., 7½ p.m. Inaugural Address by Mr. Charles Gandon, President for 1885.

Chemical Industry (London Section), Burlington-house, W., 8 p.m. Mr. B. Redwood, "The Russian Petroleum Industry."

British Architects, 9, Conduit-street, W., 8 p.m. Mr. Maurice B. Adams, "Architectural Drawing."

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. H. Blackburn, "Some Pictures of the Year."

TUESDAY, FEB. 3... Royal Institution, Albemarle-street, W., 3 p.m. Prof. H. N. Moseley, "Colonial Animals, their Structure and Life Histories." (Lecture IV.)

Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Civil Engineers, 25, Great George street, S.W., 8 p.m. Mr. David Salmond Smart, "The Design and Coustruction of Steam Boilers."

Pathological, 53, Berners-st., Oxford-st., W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m.

Zoological, 11, Hanover square, W., 8½ p.m. 1. Mr L. Taczanowski and Count H. v. Berlepsch "Third List of Birds collected by M. Stolzmann in Ecuador." 2. Lieut.-Col. Swinhoe, "The Lepidoptera of Bombay and the Deccan." (Part I.) "Rhopalocera." 3. Mr. Robert Collett, "*Echidna acanthion* from Northern Queensland."

WEDNESDAY, FEB. 4...SOCIETY OF ARTS, John street, Adelphi, W.C., 8 p.m. Mr. Charles G. Leland, "Education in Industrial Art."

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m. 1. Messrs. Cripps and Dymond, "A New Test for Aloes." 2. Mr. R. H. Davies, "Chemical Notes on some fixed Oils from Japan." 3. Mr. E. M. Holmes, "Notes on some Vegetable Oils from Japan."

Entomological, 11, Chandos-street, W., 7 p.m.

Archæological Association, 32, Sackville-street, W., 8 p.m. 1 Rev. G. F. Browne, "The Interlaced Cross at Leeds." 2. Mr. J. W. Grover, "The Old Registers of Clapham Parish."

Obstetrical, 53, Berners-street, W., 8 p.m.

THURSDAY, FEB. 5... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Howard Lectures.) Mr. W. Anderson, "The Conversion of Heat into Useful Work." (Lecture VI.)

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Prof. Duncan and Mr. P. Sladen, "Morphology of Test in *Cœlopleurus* and *Arbacia*." 2. Mr. W. Joshua, "Burmese Desmideæ." 3. Mr. Kirby, "Generic Synonymy of Orthoptera to 1839."

Chemical, Burlington-house, W., 8 p.m. Ballot for election of Fellows. Prof. Frankland, F.R.S., "The Chemical Changes Affected by Micro-Organism."

London Institution, Finsbury-circus, E.C., 7 p.m. Sir John Lubbock, "Leaves."

South London Photographic (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m. Demonstration by Messrs. Morgan and Kidd of their "New Rapid Contact Printing Process."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, "The New Chemistry."(Lecture IV.)

FRIDAY, FEB. 6...United Service Inst., Whitehall-yard, 3 p.m. Lieut. R. S. Lowry, "Musketry Instruction Afloat and the Application of Rifle Fire on Ship Actions."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Mr. G. Johnstone Stoney, "How Thought presents itself among the Phenomena of Nature."

Geologists' Association, University College, W.C., 7½ p.m. Annual General Meeting. 1. Prof. T. Rupert Jones, "Foraminifera Recent and Fossil." 2. Mr. F. W. Rudler, "Some points in connection with Volcanic Action." Illustrated by lantern views.

Philological, University College, 8 p.m. Mr. Henry Sweet, "Old English Contributions."

SATURDAY, FEB. 7...Royal Institution, Albemarle-street, W., 3 p.m. Mr. G. J. Stoney, "The Scale in which Nature works, and the Character of some of her Operations." (Lecture I.)

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FRIDAY, FEBRUARY 6, 1885.

All communications for the Society should be addressed to Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The first lecture of the third course of Cantor lectures on "The Distribution of Electricity," was delivered by Professor GEORGE FORBES, on Monday evening, February 2nd. The lecturer stated the general conditions necessary for the electrical distribution for lighting purposes, and pointed out how largely the success of electric lighting depended upon economy of distribution. He showed the necessity for considering the limits to the smallness of conductors, and proved by figures that the extra expense of laying adequate conductors was more than compensated for by the saving of constant repairs. In the comparison with gas, it was shown that the difficulties in the way of the engineers who first introduced the distribution of gas for lighting purposes were much greater than those which now meet the electrical engineer.

The lectures will be printed in the *Journal* during the summer recess.

PRACTICAL EXAMINATION IN VOCAL AND INSTRUMENTAL MUSIC.

The next Examination in London will be held by Mr. W. A Barrett, Mus.Bac. (Oxon.), at the House of the Society of Arts, 18, John-street, Adelphi, W.C., during the week commencing 8th June, 1885.

Full particulars can be obtained on application to the Secretary.

UNION OF INSTITUTIONS.

The following institution has been received into Union since the last announcement:—

Young Men's Christian Association, Stockton-on-Tees.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, January 27, 1885; General SIR J. HENRY LEFROY, K.C.M.G., C.B., F.R.S., in the chair.

The paper read was—

WITH THE BRITISH ASSOCIATION IN THE CANADIAN NORTH-WEST.

By STEPHEN BOURNE, F.S.S.

The visit of the British Association to Montreal, and the holding of its fifty-second session in that city, will mark an epoch in the history of the Association, and will, doubtless, not be without its influence on the colony to which that visit was paid. It is not likely that, for some years to come, such meetings will again take place out of the United Kingdom, for it will be long before Canada can claim another gathering, and there are few other colonies which can offer the necessary facilities. Yet there is no absurdity in the idea that, within the lifetime of all but its oldest members, progress in the arts of locomotion may render a journey to India or Australia as easy and agreeable as the transit westward last year proved itself to be. So much has been said as to the energy with which the Government and the people of the Dominion threw themselves into the movement; of the courtesy and profuse hospitality with which they prepared themselves to receive their visitors; of the ease with which those visitors were able to go out and return; of the numbers who attended the meetings, and the value of the papers presented and the discussions which followed their reading; of the excellence of the arrangements, and of the more than expected kindness and affection with which those from this side were received and cared for on the other, that it is unnecessary here to dilate on these topics. Yet the writer of any paper on the subject of the visit who should omit to refer to his own experience, would be ungrateful for the lavish attentions bestowed upon him, and forgetful of the pleasures he himself enjoyed. It would be scarcely possible to exaggerate either the cordiality of the welcome given, or the gratification it afforded to those who were its recipients; other pens than

mine have recorded all this. The actual doings of the Association have been, and will be, detailed by other participators and observers; but there may be room for something more to be said of what was seen and heard on the journey westward which followed on the close of the meeting, and to this I propose mainly to confine myself.

Mr. Colmer, in his valuable paper read here prior to their departure, told the members what there was to be seen by them. For this there was abundant matter, since everything the Dominion contained *might* have been seen by those who went; but it would be difficult to obtain a statement of what *was* seen by so many members, or even for one visitor to recount the many things which passed under his notice. I think, therefore, that the best response it is in my power to give to the invitation to occupy your time to-night, will be—taking up the special journey to the Far West provided for a body of members after the session had ended—just to narrate the events of that excursion, and that which came personally under my observation or was brought within my hearing between the time of leaving Montreal and that of returning thither. Let me premise, however, for the information of those who may be thinking of transferring themselves to the western continent, some details of the progress towards Montreal.

Leaving a spot some miles south of London, on a Saturday morning, I, with the principal contingent of the Association members, sailed from Liverpool on the same afternoon; and, though somewhat delayed by adverse winds and fogs in the Gulf of St. Lawrence, the *Parisian* landed us in Quebec on the Monday morning, thus, allowing for the change of time, accomplishing the journey from London in a little over nine days, which may be taken as the average time employed in traversing the distance,—a further period of from eight to eighteen hours, according as the land or river route may be chosen, being occupied in reaching Montreal. The sail up the St. Lawrence is one of much interest, from the many points at which charming views are to be seen on the coast, as well as from the marked appearance which the whitewashed cottages and homesteads, with the tin-roofed larger buildings, dotted all along its southern shore, present. The number of these, mostly standing each on its own small plot of land, is owing to the French law of inheritance prevailing here, which leads to the extensive subdivision of the land. Many of the owners thus find themselves in possession of a patrimony too restricted to furnish the means of support or themselves and families—but to which they are too much attached to leave—and hence resort to fishing or other means of eking out their scanty incomes, and often vegetate rather than grow or thrive. The want of progress which such communities exhibit is certainly not such as to encourage the projects, of which we hear so much at home, for breaking up estates or properties into smaller portions. The city of Quebec, beautifully situated as it is upon the river banks and the heights above them upon both sides, presents a pleasing object to the visitor on arrival. Clothed in the brilliant summer foliage, it is lighted up by the full sunshine which the clearness of the atmosphere allows to fall upon it. It is full of objects of interest, natural, artificial, and historical, but it has owed its prosperity to the lumber trade, which, with the settlement of the country, the clearance of the forests, and the deepening of the river channel, is now being carried farther to the west. Until there is a denser population in its proximity, who shall develop a more extensive range of agricultural and manufacturing industries to support and increase the trade of the place, it is not likely to revive its importance, or greatly enlarge its borders. As the seat of the local legislature of the province, and the residence for a good portion of the year of the Governor-General, as well as being the first point of arrival and last point of departure for travellers out and home, there is room for a considerable amount of activity; but the inducements for emigrants and intending settlers to remain there instead of going farther on, are not such as to indicate so rapid an increase in numbers, business, or wealth as is taking place in other parts of the Dominion. As a resting-place for the members of the Association, it afforded an agreeable detention for many during one or two days, and for a larger excursion during the week of sitting; and in no place was there a greater rendering of hospitality or warmth of welcome than it bestowed. From hence, too, a drive to the falls of Montmorenci, or an exploration of the beauties of the Saguenay river, gave vivid first impressions of the surrounding country, or produced feelings of regret at leaving both the place and the people.

Passing up the St. Lawrence, the artists accompanying the expedition, whether professional or amateur, found abundant scope for the use of pencil and brush in depicting the varied scenery on either side of the river. It

is to their labours rather than the description of one whose thoughts dwelt more on questions of economics and social progress, that reference must be made for true details of the natural aspect of the country. Montreal itself is a truly fine and very busy town. It was said that a late spring, and the scorching sun of a very hot week, had impaired the brilliancy of the garden flower-beds, but the profusion of colour and leaf shown in them, and the fine trees abounding in the wide streets of the city, were quite tropical in their character. It was difficult to think of a place where melons ripen in the open air, and tomatoes and peaches are grown by bushels, as one which is covered by snow, and its rivers fast bound in ice, for so many months of the year. Yet the inhabitants, both in the cities and the country, speak generally of the winter as a season of enjoyment; so steady is the cold, so quiet the air, and so bright the sunshine, that the depressing effects of cold are scarcely felt.

Eight days were devoted to hard Association work, quite as successful as at previous meetings at home, whilst it was difficult to find time or strength to encounter the profusion of hospitalities provided by the citizens, the enjoyment of which absorbed much of the night, as well as afternoons and evenings, and severely tested the powers of endurance of the most robust of the strangers. These festivities, however, brought residents and visitors into such close and pleasant contact, that everyone seemed to know and appreciate every other one. On the Saturday, excursions were taken by some to Quebec, by others to Ottawa, where every opportunity was afforded for those who had come so far from home to see and know all about the inhabitants, the buildings, and the trade of the place. Delightfully situated on a rising ground on a bend of the river, and below the Falls, the Parliament House and the Government buildings are stately in exterior appearance, commodious in the interior, and luxurious in their fittings up. They are built for futurity, in the expectation of a rapid growth of the community for whose government provision has to be made.

The principal feature of the place, however, is the sawing machinery, which, put into motion by the unlimited water power which falls on the river, receives, without the expenditure of any manual labour other than that involved in guiding, the trees which have been floated down hundreds of miles into the jaws of the machines, which soon convert the best timber into planks, deals, and battens of the exact shape and size which suit the markets on this side and in other countries. To economise time, through the season when the water is fluid instead of frozen, the sawing work is carried on during the night as well as the day, and this is performed under the electric light, which is here cheaply produced from dynamos driven by the same water power. It is probable that at no other place in the world are so many stacks of sawn wood to be seen at one time as at this spot, on the banks of the River Ottawa.

The proper work of the Association having been brought to a close, a large body of the members travelled westward to Toronto, from whence excursions were taken to the Falls of Niagara and other parts in the back-country. Toronto itself is a thriving city with spacious streets, lofty buildings, and the seat of much manufacturing industry. Here there was a repetition of the hospitality and sight-showing, which occupied a whole day. From hence many of the members departed to various places in the States, others having gone straight from Montreal to attend the American Association, then in session at Philadelphia; but a special party of over a hundred, accompanied by forty or fifty of the Canadian residents, availed themselves of the opportunity afforded by the Canadian Pacific Railway for a trip to the Rocky Mountains, in the district of Columbia, up to within 250 miles of the Pacific Coast.

The route pursued on this occasion was not wholly by rail, because that portion of the line which passes north of Lake Superior is not yet completed. But starting from Toronto, the ordinary train was used to Owens Sound, a port in Georgian Bay, from whence a fine line of steamers, owned and worked by the railway company, plies regularly, carrying the mails and passengers, as well as goods, through Lake Huron into Lake Superior, and up to Port Arthur, close to Fort William, an old station of the Hudson's Bay Company. The passage over these vast inland seas occupies something more than forty hours, and is conducted in fine boats having ample accommodation, provided with state-rooms as in ocean boats—admirably adapted for transit over smooth waters, but somewhat unpleasantly light and top-heavy when exposed to the sudden gales which nor unfrequently spring up, especially on Lake Superior. The waters in this lake stand at a level of some seventeen feet above

that of Lake Huron, into which they pour with great rapidity through a narrow channel, or, as it is called, the river of Sault Sainte Marie. The rapids formed by this descent obstruct navigation either way, but a grand piece of workmanship, in the shape of a fine lock, has been formed on the American side, through which, and through a canal of some half-mile in length, all vessels going up or down have to pass. The scenery here, especially near the junction, is extremely pretty, the coast-line indented with numerous bays, and studded with innumerable islands, all clothed with rich verdure. There are comparatively few houses or settlements, although the village—or, not to offend American prejudices, the city—is the centre of much business, and contains from 2,500 to 3,000 inhabitants; on the English side it is but a village. The bishop of the diocese (Algoma) resides here during the summer. His diocese is 800 miles long, contains 50,000 square miles, with 48 churches, but a population of not more than one to the square mile. Most of his journeys are performed in a steam launch, furnished by subscriptions in this country, and they take him away from his home nine months of the year. This will give some idea of the room there is for an increase of population, and a further taking up of the land, and so the using of it for the support of life.

The intricacy of the channel between the two lakes is so great as to restrict this part of the voyage to the hours of daylight, but once fairly out on Lake Superior it is as open as the sea, until nearing Port Arthur, which lies behind several islands, whose shape and appearance are very attractive. The waters of the lake are always of low temperature, the mass being so great that the summer suns have not power to dispel the coldness of the melted snow, streaming down from the surrounding hills so soon as winter is past. Arriving at Port Arthur in the morning, the progress of the excursion was delayed by an incident not of unusual occurrence, though not one expected at this season. The heavy rains which had been falling for some days occasioned several "wash-outs" on the line, some miles distant —that is, had so loosened the sand or soil on which the rails are laid as to displace the metals and flood the line. Time was necessary to allow the superfluous water to flow off, so that the ballast might be replaced and the metals relaid. The day was too stormy to permit of walking with comfort, but both geologists and botanists explored the surroundings, bringing with them numerous specimens of the flora and the strata to be found in that locality. The necessary repairs had to be effected before the train which was coming down from the west to take the party on could reach the port, and in waiting for this a whole day was lost. Thus a visit to Winnipeg, intended to have been taken on the outward journey, had to be deferred until the homeward one.

On the following morning, the line having been repaired, and the train, a special one of Pullman sleeping cars, having been brought down, a start was made for Winnipeg, distant 429 miles, which was reached very early next morning, but passed without visiting. The accommodation provided by the railway company allotted 24 passengers to each car, only half the number of seats it contained, so that there was ample room for each, and equally great sleeping comfort for the night. The general superintendent accompanied it in his own travelling car, directing its movements and stoppages to suit the desires of the party and the exigencies of the case, and telegraphing from station to station of its approach, so that the statutory number of meals might be ready at the wayside hotels on arrival. Then all turned out, the train waiting till all had satisfied their hunger. The meals, though designated breakfast, dinner, and supper, varied very little in character—at all tea, coffee, and milk were plentiful, beer and spirits at some places only, and of these very little was partaken. The staple food was beefsteaks, varied with mutton chops, the fish of the lakes and rivers, wild ducks, Canadian partridges and hares, potatoes, carrots, turnips, with bread and corn-cakes in profusion. The charge, a uniform one of two shillings for each meal, was the only expenditure necessary, the use of the train being freely granted by the company. It was originally intended that gentlemen only should go, but a few ladies, by special favour, were permitted to take the trip. Thus, throughout the whole journey, whether on board the steamer or the car, ample care was exercised to make the party comfortable. The cars having a gangway down the middle, and standing-room at each end, a free passage throughout the whole length, when they were coupled up together, was practicable, and thus, though each traveller had his own quarters, visits were perpetually being exchanged, giving to the excursion quite the character of a family party out on a picnic. At every stoppage, whether for feeding the stomachs of the travellers, or

the no less ravenous ones of the boilers and fireplaces, there was a general rush to alight. Geologists took their hammers, entomologists their nets, whilst botanists culled the flowers and grasses by the wayside, and the agriculturists examined the soil, and the various growths with which it might be covered. Pencils and brushes were brought into requisition to depict special points of interest or beauty, and searches made for animal remains, in some few instances birds and snakes being obtained as specimens. Added to this, at various places where some of the Indians came down to spy the strangers, a traffic was carried on in beads, bracelets, belts, necklaces, mocassins, and other ornaments, especially head-gear of feathers. Thus, throughout the journey, there was variety of occupation for mind and body.

But these general remarks, which apply to the whole journey, are a digression from the narrative. The route traversed on the first day was through a country very sparingly settled, the most of it being through forest land, mostly that which had been partially cleared of timber, and the wood allowed to grow again. Much of it had suffered from the action of fire, leaving the blackened trunks of the firs standing like so many funereal poles, to tell of the life that had been, and the mode of its termination. Soon after leaving Port Arthur, the line rapidly ascends, rising greatly above the sea level in about 75 miles, where the parting of the watershed takes place; on the one hand draining into Lake Superior and through the chain of lakes, finding its way into the St. Lawrence, and reaching the Atlantic ocean between Labrador and Newfoundland on the other, the drainage being northward, into Lake Winnipeg, and so on to Hudson's Bay. About one-half of the elevation is lost by descent before reaching Winnipeg, which stands some 750 feet above the level of the sea. Along the route there are various villages around the stations, with shops or stores to supply the wants of the settlers, and one of them, Rat Portage, is of considerable importance. It is situated on the edge of the Lake of the Woods, and carries on considerable trade with the Indians, settlers round about, and greatly with the navvies engaged on the railway line. Thus far there had been nothing very tempting to the eye of the farmer, but before reaching Winnipeg, and away to the south of the line, the fertile soil commences. Round about this place the land is perfectly flat, with scarcely a vestige of a tree; the ground when turned up is a deep black, without stones, and is easily cultivated. From hence, for hundreds of miles, the prairie land stretches out in all its desolation, excepting where brought into cultivation, or where towns spring into existence, as the railway laying—for of cutting here there is little or none—has rendered the places accessible, and induced settlers to come out and bring the land under culture. The whole territory is surveyed, and parcelled out into lots of 160 acres, which are freely granted to all who will take them up, on condition that a certain portion of each is actually broken up and put under crop in each of the first three years. The alternate lots only are thus given, and the possessor has the privilege of purchasing the one adjoining his holding for but a few shillings per acre. This applies more especially to land at some distance from the railway, which has, in consideration for making the line, had twenty-four miles on either side granted to it. Ultimately, the sales of these are expected to more than pay the cost of the line by which the country is thus opened up.

The whole of the day the journey lay through this prairie land, and that passed through in the night was of the same character. Though gradually rising and occasionally diversified with slight eminences, its appearance was generally that of a dead level, and in the half-light of the approaching sunrise, had all the semblance of a level sea, the hillocks being like big rounded waves. At Maple Creek, 1,026 miles from the starting point at Port Arthur, the character of the country changed. In the distance there was a long line of blue hills, rising 1,000 feet above the level of the 3,000 feet elevation which is here reached, and for many miles the course followed is what had been a river valley, hilly on both sides, ten to twenty feet flat in the centre, of unequal width, sometimes widening out like a lake, and probably formed in the glacial period by the descent of large masses of ice. Sixty miles further on, the prairie character having been resumed some ten miles sooner, Medicine Hat, on the Saskatchewan River, is reached. This place is destined to be one of commercial rather than of agricultural importance, for the soil is poor, but not altogether unfit for wheat; there is much clay and sand, very alkaline, and the water bad, and there are here bigger trees than any passed since Winnipeg. The Saskatchewan is a noble river, running through hundreds of miles, and already traversed by steamboats of con-

siderable size. Coal is found, and being worked, some distance up. With this it will become a depôt for receiving farming as well mineral products, and though at present of only fifteen months' growth, will probably increase largely and rapidly. Leaving Medicine Hat, the prairie land again spreads out, and continues, with but occasional breaks, up to Calgary, which, 200 miles further on, was reached late in the afternoon, amidst pouring cold rain. Through this part of the prairie there are abundant traces of the buffalo, formerly almost its only tenant, though now nearly extinct. Marks of their tracks proceeding southward, and hollows in the grass where they had rolled themselves in moist spots, are still to be distinguished, and the skulls and bones of those slain by the hunters are strewed about. A few flocks of blackbirds, and occasionally two or three wild geese or ducks, with some hawks, were to be seen; but here as elsewhere, there is a mournful lack of animal life, especially that of quadrupeds, and scarcely any insects.

About Gleichen, which is fifty-four miles before reaching Calgary, there were more Indians to be seen, and many families were migrating from one place to another. Their mode of travelling on horseback is very singular. Two long tent poles with the smaller ends fastened together over horses' shoulders, or hung like shafts at the side, leave the stouter ends trailing on the ground; cross sticks are fastened to make a seat, and on these goods and even children proceed over the plains, whole families thus changing their locality. The appearaace of these people is sad—life seems to have no joy except that of smoking tobacco, for which they eagerly clamour. Many of them were painted, all men and women alike, covered with blankets and wearing trousers roughly sewn, leather shoes or mocassins, strings of beads round necks and arms, and shell earrings. It is difficult to distinguish the sex, for the men are wanting in beard and the women show no bust.

Up to this point the country, except where entering Medicine Hat and crossing the Saskatchewan, and at some few other places, has not—since some distance the other side of Winnipeg—presented much engineering difficulty; but some miles before reaching Calgary the Bow river is crossed, and henceforward the windings of the river through rocky hills has required both courage and skill to mark out the track, and form the line over the next hundred miles to the summit. We entered the Gap amidst fast falling snow, which, though not lying at first, soon covered the ground. There had been heavy rains, washing away quantities of the cut timber, and making channels in the sandy soil of the embankments. The distant hills were covered with snow, and in the fading light as the storm subsided, every turn in the road brought river views of great beauty before us. Thus at midnight the extreme point of the line yet opened for traffic was reached, and the train rested till morning.

One whole day, and but one, was devoted to an inspection of the Kicking Horse Pass in the heart of the Rocky Mountains, and much more time than is at my disposal might be taken up with describing the beauties of the romantic spot, to which this long journey had brought us. Starting in the morning on a contractor's car, we were taken some five miles farther on to the highest point that the rail ascends to, and then down at the other side where it commences a descent at a gradient of four feet in the hundred, through lands that had never been opened up, or in any way cleared, until invaded by the railway engineers. The track winds through narrow channels by the river side, round sharp corners, and under short tunnels cut in the solid rock, disclosing at every turn magnificent views, now of steep hills clothed with the pine and undergrowth up the precipitous sides; then opening up the distant hills covered with snow which never melts, and again looking over the side or crossing the trestle bridge, the broad plan of the river course is seen, now sunk to narrow dimensions, but bearing marks of being often swollen by the melting of snow on the lower hills, and of stlll greater streams in bygone ages. Many miles were traversed on foot in a perfectly clear motionless air, permitting the sun's rays to light up the multitudes of distant peaks and lovely valleys, and shining with such warmth as to make shelter attractive, even though the cliff above, within 50 or 100 feet, held fast the compact glacier, of which an Irish pointsman remarked, in answer to an inquiry whether it ever melted, that "he believed the snow now seen had been there ever since there was a world." But, far too soon, the sinking of the sun behind the hills gave warning that the time for return had come, and retracing the steps of the morning, with the iron horses' service the stationary train was put in motion, and the resting place of the last night arrived at soon after dark. Here a halt was again made till early morning, when, in the words of my note-book, "at 4.30 left Laggan on return

journey, beautiful in waning moonlight and rising sunlight. Hills topped with snow, the sides showing stratification by lodgment on terraces and in crevices. Varied was the effect of multitudinous peaks, some like ships, houses, castles, humps, mostly in sharp angles, some almost perfect pyramids. Light clouds, rising amidst the snow, scarcely distinguishable in early light from the dense masses of pure white lying in the hollow and round the bases of the hills." Thus we followed the course of the Bow river, not losing sight of the range of snow hills, until twenty miles beyond Calgary, which town is 100 miles from the present end of the line. It is south of this that the largest cattle ranches are found, on one of which the proprietor told me he had 16,000 head of cattle. Entering again the prairie land, for there was no time to deviate from the one track, the train pursued its homeward course, but was stopped at various places and points —at one to see considerable numbers of the Indians, amongst them the celebrated "Crowfoot," at another to hold Divine service on the Sunday morning, at a third to visit the Bell Farm. At this farm—extending over ten square miles—there were 7,000 acres under crop this year, and an equal area prepared for additional planting in the coming season. Conveyances were provided to drive sixty of the passengers round the field, a circuit of seven miles. The cultivation here is very simple, merely that of driving the plough through the surface, dropping the seed into the loosened soil, and then sending the reaping machine to gather in the ripened crop. Comparatively little manual labour is employed, and the few resident hands find sufficient employment in tending the stalled cattle in the winter season. One feature, indicating the economy of labour which needs to be practised, is the laying down telephonic wires from head-quarters to the houses of the different head-men, who reside at the outskirts of the cultivated fields. It was calculated by Major Bell that this year he would have produce enough to load ten railway trucks every day, from January to December. The halt for service, on the Sunday morning, was quite unique. Passing by Regina, where the head quarters of the mounted police are placed, the Bishop of Ontario, who was with the party, led the way to the barracks; the wife of the commandant played the American organ, a good choir was speedily organised from amongst the men, and there, with the train standing still on the line, several Indians hanging round the doors, all joined in utilising the opportunity for worship. So many persons had never before been gathered together in that mess-room. One other incident may be mentioned; at Langevin, whilst boring for water, having reached down 1,100 feet, a rush of gas occurred, which effectually stopped further operations, and, taking fire, burned the shed and apparatus down. Not daunted by this, another hole was sunk within a few feet of the first one, and the gas made use of to produce the steam power which drives the drill. At this time, a greater depth has been reached without encountering any more carburetted hydrogen, or, as yet, finding any water.

Frequent stoppages were also made at various settlements, at many of which the mayor and corporation came to offer addresses of welcome, and to receive suitable replies. Thus proceeding onwards, night and day, Winnipeg was arrived at on the Monday after it had been passed on the outward journey. Here, vast preparations had been made in the shape of an exhibition, hastily gathered together, to show not only vegetables of huge size, and corn of the finest quality, but specimens of the coal and other mineral productions; skins of animals, and relics of the ancient history, costume, &c., of the aborigines, now, alas! rapidly approaching, like the lords of the plain, to extinction. A luncheon at the railway station; a reception by the Lieut.-Governor and mayor; an "at home" at Government-house, and a dinner at the principal hotel, all testified to the cordiality with which the Association's visit was welcomed, and the profuse hospitality of the citizens who did it honour.

The city itself is a witness to the marvellously rapid growth of population and buildings. Seven years ago it had but a few huts to mark the spot; now there are 35,000 inhabitants. Its banks, stores, hotels, and private residences are of handsome elevation and large dimensions, and though its wide streets are but straight spaces of unpaved soil, which in such rains as poured down on the day of our visit becomes mud, literally axle deep, there is a tramway laid down in the centre over which cars are constantly running in all directions. The foot pavement consists, as it does in Montreal and Quebec, almost entirely of planks laid on and bolted to sleepers resting only on the bare earth.

After spending the day thus, the train left at dark, expecting to reach Port Arthur the

next morning, but a singular accident detained it nearly a whole day at Rat Portage. A break-down train having been summoned to relieve a disabled passenger train coming westward, on passing over a high trestle bridge, the foundations of which had been loosened by heavy rains, broke through, precipitating the engine in pieces to the bottom some 40 feet down, and the crane-truck, held back by the car behind it, hung over the gap, its front wheels suspended in mid-air, whilst the hinder ones held firm to the rails. After waiting some eighteen hours, the two trains from opposite directions each backed up to the broken bridge, passengers and baggage were exchanged, and both returned instead of proceeding onwards. This may illustrate some of the difficulties to be encountered in the infancy of settlements, and the fertility of resources to meet the emergency. The detention being thus ended, Port Arthur was reached a day behind time; voyage taken over the lakes, and Toronto arrived at on the afternoon of the fourteenth day after starting from it. The party here broke up, some of its members travelling as fast as possible through to Rimouski to join the homeward steamers; some stopping to visit Niagara and other places, and then on to more distant parts. The remainder, after one or more days, using their excursion tickets to return to Montreal, from whence they had commenced the journey.

So much time has been occupied in narrating the actual journey, that too little space is reserved for what should have been the real purport of this paper—a disquisition upon the capabilities of this part of the British Empire for occupation by the increasing numbers of our home population, and their freedom there to develope into a new nation. Yet it seemed difficult for the writer to shorten his description, since every line called up remembrances of some spot or some scene which had absorbed his attention, either from its novelty or importance. The like advantage not being possessed by the hearer, it is to be feared that what has afforded the author so much pleasure in trying to depict, may have been wearisome to those who have not his recollections to fall back upon. If, however, what has been said has been of any interest, it may not be without some use as an incentive to some to "spy out the land" for themselves, or to assist and encourage those who may be already inclined, whether from choice or necessity, to gravely consider the prospect of seeking new homes.

Starting from a little west of Winnipeg—say, in the 95th meridian of longitude—onward beyond Calgary to the 115th, and looking downwards to the 49th parallel—the United States boundary — upwards to the 54th, we have a wide expanse of country, 800 miles by 300 miles, of which the one-half or three-fourths is fitted to be the feeding ground of as large a resident population as can be employed in its culture and accessory occupations, by whom there can be raised an amount of food more than adequate for an exchange with those in the home and other countries, who may in turn manufacture all those other products which the necessities or desires of civilised life may require. Montreal, to which the largest ships now have access, is distant but ten days from London, for, as was proved on this occasion, passengers leaving here on the Saturday were landed there on the Tuesday week. From Montreal, even now that the route is partly by water, it would be possible to start the same night, and arrive in the centre of this district on the Saturday following. Thus within the fortnight we may be transported from the dens of St. Giles, where scarcely a foot of ground is uncovered, to the plains of Regina, where there are miles wholly untenanted. We have but to see, smell, and hear the foulness of the one, and then to turn our gaze upon the sweetness of the other, to see that there is some fault in our economic arrangements that the two are not brought together; the starving hundreds here to the luxurious fields and soil there, which need but the hands which cannot find employment here to bring forth there abundance of that for want of which they are perishing. Civilised man has exterminated the beasts which roamed over the rich prairies, and debased the Indians for whom they were the hunting grounds, and yet hesitates to go up and possess the land that lies open for his use. It cannot be but that this visit of the Association must result in extended knowledge disseminated at home, and an emulation of the conduct of the sons of Jacob who, when they heard that there was corn in Egypt, instead of remaining to look upon one another, went down, first to buy, and then to settle and grow for themselves.

No doubt there are difficulties in the way, but what is there in this life which is worthy of possession that can be obtained without encountering such and overcoming them. Let us imagine a little what they are, and, first, of the climate. The season of this visit was in the summer, and we saw nothing of the rigorous winter which reigns there for many months of

year; but we heard from those who had both seen and felt, that it was by no means the dismal period we too often find it in England, especially by those who have scanty food and short supplies of fuel. Though the thermometer sinks low, the sun shines brightly, the wind is still, the frozen snow makes hard tracks, over which the produce raised in summer can be easily transported through the winter. The purity of the air gives briskness to the system, and there is a sense of enjoyment, whether in labour or pleasure, which makes the season far from distressing to those who are hale and hearty. Then the summers are almost tropical or sub-tropical in their brilliancy; vegetation is rapid, as if nature rejoiced in liberation from the bondage of winter. Wheat sown in April has been reaped in September. Potatoes, carrots, turnips, lettuces, cauliflowers, and cabbages, with various other products of huge dimensions, were exhibited at various places, whilst tomatoes and melons grown in the open air and maturely ripened, bore evidence to what the soil can bring forth. The Rev. W. Huleatt, who was instrumental in sending out emigrants from Bethnal-green in May, was early in October bringing home fine specimens of grain and vegetables which these same persons had grown on their own land, in the interval between their arrival and his departure. Nor were these the fruits of skilled agricultural labour, for those who raised them were essentially townspeople who, up to their leaving England, were but artisans or petty traders. For at present these prairies, on which there are no trees to cut down and grub up, nor stones to remove, require but sending in the plough to turn over the prairie grass, putting in the seed, and then reaping the product when ripe. Indeed, the practised English farmer is in danger of despising the simple method employed, and, by pursuing English systems, of reaping less than the uncultured labourer does. It is true that when the first fertility of the soil slackens, knowledge of drainage, manuring, and rotation of cropping will have its value, but this may be gained by experience and gradual teaching long before it becomes of essential need.

Then as to sale and transport of all that is raised, beyond consumption on the spot, lands which before must have been useless are now available by the opening of the Canadian Pacific Railway, which, already traversing the entire breadth of the continent, or which at least is about to do so this year—will, so soon as settlement at distances from the trunk line is general, throw out its branch lines, in both directions, and collect and feed the traffic of places now somewhat unapproachable. The same means will remove the difficulty of obtaining supplies. The marvellous rapidity with which stores and shops spring up and are furnished with goods, bears evidence to the fact that where population is created, there the caterers for its wants will bring their wares. So, too, will places of worship, schools, medical and legal practitioners, literary and social privileges—all be found forthcoming as the country becomes filled. At present there is but little deficiency in meeting actual necessities, for the vastness of the country diminishes the effect of distance. Many artificial wants cease to exist, and the effort to supply real ones is put forth when the necessity arises. This is proved most strikingly as regards alcoholic liquors. In the towns there is probably as much drinking as in many parts of our own country, for Englishmen are prone, not only to carry their own bad customs with them, but to indoctrinate those among whom they come, but the entire prohibition in many parts, and the diminished use in others, shows that there is no real necessity for such supply.

Again there is the difficulty which, without disparaging love of country, or attachment to English soil, friends, and surroundings—for I have myself known what it was to transfer my home much farther off than Canada, and to rejoice in being able to make it again in old England—I cannot but deem a sentimental one. Fifty years ago, to become a colonist was to be far away, and possibly for ever, from all one held dear, with but few opportunities of exchanging even letters with those left behind. It was to settle either in almost solitude, or amongst those of a different race; but now, and especially in a hitherto unpeopled land like that of the Dominion, where there is but a few days distance between him and those he leaves, it is, in fact, attaching the new place to the old—not detaching the person from his country. He is accompanied by many by or to whom he is known, and he finds there those who are neither aliens nor strangers. It is surprising to note the difference of feeling between the isolation one had to endure in those days, and the thorough sense of being still at home, which the difference of the surroundings then and there to what they were on this recent visit, gave rise. The contrast between Jamaica in 1834 and Canada in 1884 was, in these respects, truly surprising.

Many other subsidiary obstacles might be

enumerated; but, after all, the one of greatest difficulty to overcome is that of expense. Men may, and ought, perhaps, in many cases to go out for one season first, but it is families that are wanted. Home life can never exist without the women and children. There is plenty of room for these, with work for them as they are able; not to the undue extent which poverty, sickness, and drink render needful here, but in that wholesome measure which contributes to happiness, and fosters growth into true man and womanhood. The transport of such is costly to begin with, but economical in the end. To a limited extent this has been tried by several philanthropists. The effort which Mr. Huleatt told me of is a good sample. For ten families, £1,000 was set apart, not as a gift, but a loan, and as each one obtained a free grant of 160 acres of land, £100 was made a first charge upon the property. From the progress made in the first year there is little room to fear that three years' occupation and culture will not render every plot worth the whole sum. This £100 was devoted in the proportion of about £30 for personal outfit and conveyance to destination, and £70 to plant and stock for the farm. Now, looked at as an investment merely, this is not unpromising to the philanthropical capitalist; but to meet the necessities of our own people and the wants of the colony, there must be something far more extensive than is likely to be undertaken by private persons. The State had far better thus invest some of the sums it now squanders, and even, if it need be, come upon the pockets of the tax-payers, than allow the evil to continue longer to endanger the security of our institutions. The monies now bestowed upon indigents and paupers, and the drains made upon the benevolent for charitable purposes, only stop the flow of rivulets, whilst the rivers are rising unchecked until there is real danger of their speedily overflowing their banks and drowning us altogether. The details of such assistance cannot be entered upon here, they must be settled after due consideration, when there is a consensus of public opinion as to its necessity. It may not, however, be trivial, or impertinent, to ask why we should continue to erect and maintain, either at public expense, or by charitable aid, our orphanages, and schools for the indigent, or even our reformatories and poorhouses in this country. Why not place and keep them up across the Atlantic, not by burdening the colonists, but from the same sources as at present? Those who are thus sheltered and cared for, especially the children, would be training for usefulness in new homes, and would pass through the period of probation in far less time than they do at present, to the manifest diminution of cost from its shorter duration, and the fewer establishments that would be needed.

Nothing has been hitherto said as to the capacity of Canada for absorbing the surplus population at home, in developing its mineral resources, or for prosecuting its fishery operations, for this reason:—That the earliest because the most simple pursuit, and that which is the readiest to hand, is the extension of its agriculture. Neither has allusion been made to the forthcoming completion of the line to the Pacific, and the through traffic to China and Japan which is expected to pass over the route, in affording an opening for numbers in the working of the traffic, or in ministering to the wants of its workers; because simultaneously with that completion the large body of those now engaged in its construction will be more than equal to the new or additional employment, there will be need of on the line itself. Should, however, the anticipations of the Company be at all realised in the numbers who will come out as settlers, or the accommodation that will be required for them, and the transport of the produce they raise, branch lines will be formed in every direction, and thus for years to come require the services of all who are now engaged upon making the main line. The tendency to increase in all these ways will provide abundant openings not only for agriculturists, but also for the subsidiary industries which they will create.

In another direction I must, at the certain risk of differing with my Canadian friends, express dissent from the policy pursued, of fostering manufacturing operations by the aid of protective duties, in order to shut out the produce of the mother country, as well as that of foreigners. The first efforts of a new country should always be directed to develop its own resources, to cultivate those industries for which it possesses special advantages. These for Canada seem to be the raising of corn and vegetable products upon its rich soil; the capturing of the fish which swarm in its seas and internal waters; the breeding of stock for the butcher, and still more, the manufacturing of dairy products; the extraction from beneath the surface—oftentimes from the hill-side or the plain level, so as to need no sinking of shafts—of coal, phosphates, metallic ores, and, it may be, other mineral products, with

which its mountains and valleys abound. In fostering all these, attendant mechanics, artisans, professional men, teachers and ministers of religion, will likewise be brought to the spot, and in their turn require additional agricultural labourers, miners, stock-minders, shopkeepers, and merchants—all tending to fill the land and consume its produce. But whilst all these sources of employment, which lie ready to be taken up, are not fully availed of, it does seem to be contrary to every sound economic principle to encourage the manufacture of those articles which can, as yet, so much better be sent out from this country, as is evidenced by the necessity for subsidising colonial producers through the imposition of protective and prohibitory import duties. To import raw cotton, for instance, from the States, steam-engines and mill machinery from England and elsewhere, with skilled and, therefore, highly paid, labour to work and direct these operations, for the purpose of raising up factories, and to maintain these at the cost of enhanced prices to the agriculturist, the fisherman, and the miner, is not, and cannot be, a sound policy. The corn grower and others cannot recoup themselves by extra prices for their articles, because they have to compete with unprotected producers in the markets they seek; and, aided by the present low prices, it cannot be long before they see the folly of supporting monopolies in the benefits of which they themselves have no participation. The true policy would seem to be for each portion of the globe to raise or manufacture that for which it possesses either natural or acquired facilities, and freely to interchange these products between settlement and settlement.

But such a course is in another way suicidal for the Dominion. What it requires above all things is to draw thither a population to work its fields and its mines. These abound in the old country, but cannot, without assistance, transport or settle themselves in numbers at all adequate to the colonial need. That assistance may, and, I believe, must come from the State, the capitalists, or the philanthropists at home, and it is certain that none of these will yield it in any large degree, when it is seen that, by so doing, they are swelling the colonial exchequer, or fostering rival manufacturers to the exhaustion of their own purses, and for the maintenance of manufactories to undersell their own. It is a prevalent notion that England is so overburdened with population that it is a charity to her to cart it away like so much rubbish. If it be so, then England's days of prosperity are numbered, for however great her wealth, she never can stand the continued exhaustion of breeding and rearing adults to spend their strength in other lands. When money is abundant, the Bank of England may have its coffers full of gold, by the employment of which in loans and discount she gets a return for her investment; but her doors would soon have to be closed did she distribute her sovereigns or bank notes to fill the empty pockets of all who would take them. Just so every worker whom England has to spare is so much capital for the loan or gift of which she must seek to be reimbursed. To send these abroad to raise food which she may purchase and pay for in the products of her manufacturing industry, will be a safe and profitable investment, benefiting alike the lender and the borrower, or the giver and the receiver. If wisdom rule in the councils of the State, and prudence guide the administration of private investors and philanthropists, Canada will never be assisted to receive settlers in anything like the quantity she needs, so long as she declines to receive with them the manufactures by the sale of which our own people have to live and flourish. England's help must be withheld from those, be they colonists or of other nationalities, who continue to maintain hostile tariffs, and must be extended to those only who will meet her upon terms of the equal freedom she accords in her trade with all.

DISCUSSION.

Mr. TRELAWNEY SAUNDERS said he would not follow Mr. Bourne into questions of political economy, but would simply express the immense enjoyment he had himself derived from his visit to America. It was worth while running the risk of a storm on the Atlantic, for the sake of a voyage up the St. Lawrence, from the Atlantic to Montreal, and especially of the voyage down from Lake Ontario to Montreal, through the Thousand Islands and the rapids. He had just a week to spend betweeen his arrival in Montreal and the opening of the British Association meeting; and in that interval he went as far as Winnipeg, by the Canadian Pacific route, and came back by the States, through Minneapolis, Chicago, Detroit, and Niagara, touching at every one of the great lakes. He must confess that the sight of Winnipeg astonished him. He had been engaged for many years in endeavouring to develop this north-west territory, to rescue it from the hands of the fur hunters, and utilise it for the cultivation of

mankind, and he found this place—which he had known by the name of Fort Garry, a mere fort of the Hudson's Bay Company—was now the commencement of one of those extraordinary cities which seemed to grow up in a night. The main street was 130 feet wide, and already possessed buildings which would do credit to any capital in Europe. Coming to Chicago, one could hardly believe that it had arisen from the flames in ten years. He did not know how many miles he rode on a tram-car, from the banks of Lake Michigan out to the stock-yards, which he visited for the purpose of seeing the accommodation provided for the trade which had to be done. One remarkable feature about them was a timber viaduct, which ran right over the market, and from which you could see all that went on underneath. From the 8th to the 26th of August he never slept in an hotel, but in steamboats or cars. The meeting of the British Association at Montreal was most successful, there being a larger number of old members than the average in England. The whole journey from Montreal to New York was most enjoyable, the scenery all the way being a constant source of attraction; and there was this great advantage, that wherever you went you always felt at home, which was not always the case at a much less distance.

Mr. Cornelius Walford said he did not accompany the British Association on their visit to the North-West, but he was familiar with the country, having visited it from time to time and studied its probable future, especially in relation to the United Kingdom and its inhabitants. Many years since he thought one of the primary objects of promoting emigration from England to the North-West was the production of grain, and he still thought one of the main objects should be the cultivation of the soil; but he had learned to see that those who went there with the object of cultivating grain beyond their own immediate wants, were entering upon an enterprise somewhat in advance of the facilities which existed for turning it into cash. The railway certainly offered some facilities which did not previously exist, but that was not its primary object. The railway was a great international undertaking, its object being to unite the British dependencies west and east throughout the world. The really practical questions were, what were the requirements of the North-West, what were the facilities it offered, and what class of persons should be advised to go there He thought those who went there to grow grain for profit would miss their mark, but there were many things to turn to. One of the most promising industries which might be greatly developed was the catching and curing of fish, and another was the development of the mineral resources, but there again came in the question of transport. The rearing of cattle had been referred to, but as far as his experience went, sheep were out of the question, and no stock could be profitably reared in any country which had intense frost for four months in the year. The mechanical arts would afford many openings as the country developed, but all these points had to be considered before inducing people to settle there. Every one who went, whether he had much knowledge of agriculture or not, could grow grain enough for his own purposes; but that was not all, the grain must be turned into money in order that the other necessities of life could be obtained; and after great consideration of the question, he thought the agricultural prospect was not, on the whole, a good one. Towns would be formed, and industrial communities and artisans of many kinds would find homes there in the future, but the promiscuous transport of emigrants to that country was a matter for very grave consideration. He did not wish to throw any cold water on the pleasant prospect which Mr. Bourne had painted, but those who went out there to found their fortunes must consider their constitutional adaptability to the climate, and also the means by which they were going to become a wealth-producing community. If these points were attended to, no doubt Mr. Bourne's paper would produce the result he wished, the greatest possible good to the greatest possible number.

Mr. J. G. Colmer, after complimenting Mr. Bourne on his paper, said it had an additional interest to him, from the fact that he had had the advantage of travelling over the same ground during the past year, and he could confirm generally what had been said. What struck him most was the great progress which had been made since he first became acquainted with the country. In 1878, when he was last in Canada, Winnipeg had only just received the advantage of railway communication, and you could not get much further; but when he visited it five or six years later, there was not only one city of 30,000 inhabitants, two of over 3,000, but many others of over 1,000 which were rapidly increasing. The railway had been extended to the Rocky Mountains, and the population had increased from a few thousands up to nearly a quarter of a million. He took as much opportunity as possible of talking with the settlers themselves, so as to get at their ideas as to the climate, the productiveness of the soil, and their future prospects, and the replies generally were most satisfactory. Sometimes people returned, and made complaints which, when examined, were frequently found not to arise from the unsuitability of the country, but from the unsuitability of persons to the life they proposed to lead. Undue attention was sometimes attached to these complaints, whilst those who gave more favourable accounts were often supposed to have some ulterior motive. Similar statements had been made with regard to other parts of Canada, Ontario, for instance, which, years ago, it was said could not raise either grain, cattle, or fruit, though in truth there was no part of the world which could compete with it in that respect. Within the last 100 years, the population of that province had

increased from 100,000 to nearly 2,000,000, and he ventured to prophecy that Manitoba, and the North-West would also rapidly increase. He would remind Mr. Walford that agriculture must be the basis of the prosperity of any country, and afterwards commerce and manufacture would follow. There was nothing to prevent the growth in Manitoba of almost any kind of product which temperate countries could produce. Cattle had increased from 3,000 or 4,000 in 1881 to 50,000 in 1884. Last year the losses during the winter did not number more than 1 per cent., and the ranch men told him that their increased stock for the past year amounted to 50 or 60 per cent. Cattle were being driven to the Canadian Pacific Railway from the United States for transport to Chicago for slaughter, and he thought there need be no fear, having reference to these circumstances, of the ultimate success of the cattle industry in the Rocky Mountains. With regard to the tariff, he would only remark that the Canadians were permitted under the constitution to arrange their own fiscal policy, and he thought the question of the tariff might very fairly be left to themselves. In conclusion, he would say he knew that the Canadians had been very proud to welcome the British Association, and retained recollections of the visit as pleasing as those who went from England.

Mr. H. Trueman Wood said he had little to add to what had been said by Mr. Bourne, especially as he did not accompany the excursion to the Rocky Mountains, having undertaken duties in connection with this year's Inventions Exhibition which necessitated his visiting Philadelphia instead. He regretted at the time not being able to go to the North-West, and had done so more since, for he found his friends' recollections of the trip were gradually brightening. At first there seemed to be a little question whether it was worth while to spend a week in a railway train for the sake of one day in the Rocky Mountains, and then another week on the way back; but all that seemed to be now forgotten, it was a delightful trip, and it seemed to get more and more delightful as time went on. He could not but bear testimony to the great kindness and hospitality with which the British Association were received, all their wants being anticipated, and every arrangement being made for their comfort. He wanted to ask whether something could not be done next year, when a great many Canadians would be over here in connection with the Colonial Exhibition, to show that the members of the British Association were really grateful for the kindness then shown. We could not take them about England free, our railway companies not being quite liberal enough for that, but still something might be done. The matter had been suggested to the Royal Commission which had charge of the Exhibition, and he was not without hope that if those who went to Canada would bear it in mind, and give some help when the time came, something might be done, not only to show gratitude to Canadians, but also to show that gratitude which had been described as a lively sense of favour to come to the Australians, for as soon as the voyage was made rapid enough, there was no doubt that the British Association would meet in that colony. It might be interesting to state, with regard to the McGill College medal, the idea of which originated with Professor Hele Shaw, that £540 had been collected, which after paying all expenses would, when invested in colonial securities, yield more than £20 a year, the whole of which would be devoted to the medal, the Council of the Association having undertaken to provide the die.

Mr. Liggins said his experience of Canada went back twenty-five years, so that he could speak with some authority on the question of emigration. He agreed with almost everything Mr. Bourne had said, and though he had not been in Canada in the winter, he understood that there was more enjoyment there in that season even than during the summer. There was no finer soil in the world, and he had not seen any cultivation in the United States which could compare with that of Canada. You always felt there that you were amongst your own countrymen, which gave the place a great advantage over the United States, where the people were of all nationalities. Still it must be remembered that the climate was six months of winter every year, and he did not agree that agriculture was the only employment which should be encouraged. In his experience, the most successful people were strong, skilful, agricultural labourers, who were able to turn their hands to anything; no other class of men who had gone into farming had escaped serious loss. The railway ran for a thousand miles in a straight line, and almost all the lands near to it were already appropriated, so that the distance to go before reaching the railway was a serious difficulty to farmers. There must be some industry to employ the people during the six winter months, and, therefore, though he agreed in theory with the concluding portion of the paper, he did not think it would be practicable to carry it out. The greater portion of the population was poor, and it would be impossible to raise the necessary revenue without import duties which were not intended to be protective or prohibitory. At this moment negotiations were going on between Antigua and Canada with reference to free exchange of imports, but there was this difficulty with the Canadian Government, that they did not see their way to raise the revenue by any other means than customs duties. He should advise everyone to encourage emigration to Canada rather than to the United States.

Mr. David Chadwick said he made half the journey to the Rocky Mountains with the British Association, that being his fifth visit, and being to some extent familiar with the country, and the value of land from Quebec to California, he might be allowed to say a few words. Very great praise was due to Mr.

Bourne for his interesting, pithy, and emphatically truthful paper, which depicted very graphically the great resources of the country, the fertility of the soil, and the healthfulness of its climate. There were no doubt six, perhaps seven, months of winter, but the remaining five or five and a-half months of summer was summer which ripened grain and every other product in a most extraordinary manner. The whole district of Manitoba, and the North-West territory, might be said to be one vast plain of prairie land, and if there was one little mistake in the paper, it was where reference was made to the possible use of manure, for in his opinion there would be no need for it for the next fifty years. He, in connection with fourteen or fifteen other Englishmen and Scotchmen, were proprietors of land in Iowa, where they grew corn, and it was a well-known fact that in Illinois, the adjoining state, corn had been grown for forty years without a particle of manure. Manitoba was equally fertile, and the grain was of a better quality, and obtained a better price than that from any of the Western States of America. There was no doubt of the healthiness of the climate, but it required a sound body, and disposition for physical labour. With those conditions, there was no country to which a person could emigrate with greater probability of increase of years, and thorough healthiness of life. As had been stated in the paper, Canada, Manitoba, and the North-West, afforded the most delightful residence for all who could labour and wished to live by their labour, or had sufficient capital to start in the business of farming. He regretted that Mr. Bourne had concluded a very admirable paper by touching on the debateable point of free trade and protection, which it was not possible to discuss, and, of course, he would not express any opinion upon that. He would only give one illustration of what could be done there. A friend of his, who within twelve months was a merchant in Mincing-lane, had now grown a crop in Manitoba, 300 miles from Winnipeg. When he was there, it was only eleven months since the time his friend left London, but he had settled down there on a farm of 640 acres, and had all the advantages which Mr. Bourne had so strikingly described.

Dr. EDMUNDS also regretted that the question of free trade had been introduced, as this was entirely one for the Canadians. If they chose to educate their people in manufactures, the cost of doing so was for them to consider. With regard to the emigration question, he spent two months last year in going chiefly to the Rocky Mountains, and examining that great country in the North-West. He made a point of talking to as many farmers and their wives as he could, in order to get information at first hand as to how those who had gone out recently had succeeded, and he was bound to say that the facts he had collected entirely bore out what had been said by Mr. Chadwick; that men who went out with no special preparation, but with a small capital, with determination to work hard, and who were in good health, did well without exception. Those who went under conditions, and with the qualities which any reasonable man would say deserved success, had had a real and substantial success. He did not hear of a single failure, except amongst wasters and loafers such as were sometimes sent out, some to whom one would not lend a sovereign, who had worn out their characters, who could not live without Bass's ale three times a day, and who had never earned a shilling honestly in their lives; yet such men went out to Canada, with £100 and letters of introduction. A friend of his told him he had fifty such fellows sent out to him during the last three years, and now he had to put such letters of introduction in the fire. He said, people had come out who were gentlemanly fellows, and he had asked them to dinner, but within three months he had had to go and bail them out of the police-court, and pay their debts, or see them go to jail. It was these men who on their return spread disparaging reports of the country. He had visited the Bell Farm, and there saw 100 square miles, under conditions which Major Bell told him enabled him to send ten car-loads of wheat per day down to his railway station for England; that he could ship the wheat on the railway-car at Indian Head for 13s. a quarter, and pay eight per cent. on the capital invested. He also told him that so long as wheat fetched 27s. a quarter in Liverpool, with only the present facilities of transport, he could make eight per cent. on any amount of capital invested in the cultivation of land. The land he travelled over there was amongst the finest on the face of the earth, and men there could live the healthiest life possible, apart from those factors of refined civilisation such as could only be obtained in London or other great cities. Such a power of manufacturing wheat really meant that the present condition of agriculture in this country was not one of temporary depression; there was a revolution to come over the country, and the land now devoted to the growth of cereals and the legumenosæ must go out of cultivation, and would remain out of cultivation, and fail to produce rents to idlers as it had hitherto done, until the time came when it would be utilised for villa residences and garden properties, or dairy produce farms. Mr. Walford had disclaimed the notion of throwing cold water on emigration, and yet he certainly spoke in such a way as to dishearten their poorer brethren, who ought to be encouraged to go out there, and take part in developing this great country. Any grown man, over eighteen years of age, could now go to Manitoba and have a fine farm on which there was not a tree to cut down unless he chose, half a mile square of alluvial land fit to put the plough into at once, and pay nothing but a two guinea survey fee. He could also pre-empt the adjoining half mile square of land for a sum amounting to £40. He had to pay altogether 10s. an acre for

this, but as soon as he had complied with such reasonable conditions as any honest settler would comply with, he got half that money returned to him. This being the condition of things, he thought it was the duty of all who were acquainted with the facts to stand up and bear testimony to them. When something like 1,000 a day were being added to the population in England, they had not to consider whether they could spare these people, but they were called upon to look on the poorer members of the community as the father of a family looked on those growing up around him, and the State ought to assist our people to go out there, and to help to form new settlements to bind up to us in ties of love and affection the great country which was destined to hold 100 millions of people in comfort and happiness before the next century was completed.

Major CRAIGIE said he could not altogether agree with the remarks of the last speaker as to the enormous future he had opened. No one would accuse him of a desire to depreciate the great Dominion, but there seemed something in a large continent which irresistibly enlarged one's ideas or the terms in which they were expressed, and he could not help feeling that, both in Canada and the States, all accounts one heard must be taken by a careful man with great caution, and with some discount for exaggeration. He also went over the Bell Farm, but he could not agree that it would be a tempting prospect for an English capitalist to place his money in farming that particular district at the present time with wheat at 27s. a quarter at Liverpool. He did not say that a vast deal more wheat could not be grown there, but taking one year with another, and considering the risk of the seasons, and the cost of transit, which could not always be diminishing, he did not see what prospect there was of fortunes being made by sending wheat to this country at 27s. a quarter. He found within 150 miles of Winnipeg there had been ten times as much wheat raised last year as in the one previous, and he could not help reflecting what would happen if this were to go on. They had seen already how the price of wheat had gone down with increased imports from India and America, and he thought it would be both foolish and impossible to rely on that one product in the future as the emigrants' stand-by. Those who went out from this country must go in for mixed husbandry, and for producing those different productions for which that great dominion was eminently fitted. He did not agree with Mr. Walford that cattle and sheep could not be wintered. In certain districts it was likely to be a large industry. He saw some of the first flocks of sheep being driven over the frontier, not far from Fort McLeod. In that immediate district sheep would not probably do well, and they certainly would not be welcome; but further on, north of the Bow River, there was land quite capable of maintaining sheep throughout the year in very little shelter. In that direction there would be a great opening, but he did trust an impression would not be given that men ought to be sent out from the slums of St. Giles to the plains of Regina, simply to grow more wheat than was wanted.

Mr. J. S. O. HALLORAN said it must be borne in mind that the pioneers of colonisation always had many problems to solve, and many difficulties to encounter, from which those who followed them reaped the chief benefit. When they heard of denizens of the East-end of London being planted as farmers in the Canadian Far West, it seemed something like throwing a child into deep water by way of teaching it to swim. That so many of this class had succeeded spoke volumes for the capabilities of the country. As to stock-raising, he imagined that the open prairies between Winnipeg and the Saskatchewan could hardly compete with Australia and South Africa, where sheep and cattle thrive without shelter or artificial food all the year round; but under the shelter of the Rocky Mountains, where the influence of the Chinook wind tempers the climate, there is a district which appears to be well suited for cattle. As to the future of this great region, he firmly believed that as civilisation advanced, as more land was brought under cultivation, and as trees were planted—for that was one of the greatest necessities—the North-West would not be surpassed by any part of Canada, either in productiveness, or as a desirable place of residence.

Mr. BOURNE, in reply, said he did not wish to raise the question of protection or free trade, but he did feel that in dealing with the question of emigration he was bound to point out what he believed would be an insuperable obstacle to the extensive settlement of the land, viz., that the occupants were not only saddled with the expenses of maintaining their own cultivation, and competing with low prices, but forced to pay more for all articles which they cannot grow themselves, including even the instruments of husbandry, in order to protect the manufacturers of the colony. It was not to be expected that the English public would find money to transport labourers to those soils, if, when they got there, they were exposed to these conditions, to the detriment of those who were left at home. This was a drawback which, to his mind, must be overcome before it would be feasible to send out there the large number of emigrants the colonists looked for, and without which they would suffer materially from the large expense incurred in making the railway, and opening up the country. He thought Dr. Edmunds had a little exaggerated the sanguine expectations of Major Bell. He saw that gentleman, too, but did not remember hearing the figures quoted by Dr. Edmunds. He did hear 20s. or 22s. spoken of as the price at which wheat could be delivered at the railway station adjoining the farm; and even that was called in question at the time. Certainly the

present price of wheat was so low as to discourage its growth. It had been said that the import duties were levied for the purpose of revenue, and not for protection; but the distinction was perfectly well-known to all economists. If a customs duty was levied for revenue purposes only, as in England on spirits, &c., precisely the same duty was levied on the same articles manufactured in the country, and then there was no protection. He had not alluded to the Scott Act, because his name was so well-known in connection with the temperance movement, that he did not feel disposed to ride his hobby on this occasion. But he made special inquiries as to the effects of the prohibitory Act, and found that even those who liked a glass of ale or wine so strongly felt the advantage of the prohibition to those who would misuse it, that they willingly acquiesced, and exercised a little self-denial for the general good. He could only wish the same spirit were manifested more extensively in our own country.

The CHAIRMAN said he feared some misapprehension existed with regard to the Bell Farm, of which so much had been said. According to the reports of numerous gentlemen who had interviewed Major Bell, the estimates he gave of the price at which he hoped to be able to put wheat on the Liverpool market varied very considerably. The price of 20s. per quarter had undoubtedly been named to Professor Sheldon and others, and his contention was that, admitting the possibility of a great wholesale concern, growing wheat at that rate, the smaller farmers could not do so; and the natural inference was that they would discontinue or reduce the cultivation. The statement that the estimate was 27s. somewhat altered the question. He was surprised to hear it said that the soil was practically inexhaustible, and would not need manure for an indefinite period of time. He remembered when the great wheat-growing country of the United States was the valley of the Gennessee, but that district had been for many years exhausted; and in like manner a large area in South Australia had become exhausted by growing wheat continuously without manure. In the immediate future he thought there would be a great increase in stock raising. It was true the severity of the winter was a difficulty, but the grass grew very long and became dried into something like hay, which the cattle found by scratching away the snow from the surface, and were thus able to subsist in the open air even in winter. As had been already said, the great lesson for people in the North-West was to vary and diversify their farming, and place it on as broad a basis as possible. The immense rush into wheat was a mere accident of moment, and probably five years hence a very different system would prevail. He could not agree with the slight discouragement which had been thrown by some speakers on the emigration of the labouring classes. He considered they owed a positive duty to their fellow beings who were struggling for existence under conditions of the most abject poverty, to remove them to the land which invited them; and which could receive all who were likely to be taken away by either public or private effort, and more. Every man who was sent out was converted from a miserable, discontented, dangerous element of society, into an independent proprietor and consumer of our manufactures, so that there was a double benefit. He was raised in the scale of civilisation, and at the same time helped to extend the market for our own products. He concluded by tendering to Mr. Bourne the thanks of the Society for his very able and interesting paper.

Mr. HYDE CLARKE writes: — Mr. Bourne was understood to attribute the divisions of land in the Province of Quebec to "French law." This is liable to misunderstanding. "French law," or the "law of France," in this sense, did not exist at the French Settlement of Canada, nor for a century and a half later. Each province of France had its own law administered by its own "Parlement," as, for instance, the "Coûtumes de Normandie," which now exists in the Channel Islands. At the foundation of Canada the system of law assigned was the "Coûtumes de Paris." A general law of France did not exist until after the French Revolution, and this was consolidated by the Code Napoléon, now administered by us at the Mauritius and St. Lucia. The main basis of inheritance established in Canada was that of primogeniture in the Seigneuries, which, as feudal institutions, did not provide for the division of subinfeudations by inheritance. The subdivision must be due to another cause, and that an obvious one. The *habitans* having increased twenty-fold, have remained on the Seigneuries and the old provinces, only leaving to be *voyageurs*, the migration to the factories in the United States being quite recent. The seignorial tenures being relaxed, subdivision has naturally taken place, as in some parts of New England. With regard to cropping the deep soil of the prairies, this takes place all over the world, under the like circumstances. I have had land under my control which must have been cultivated for centuries, if not thousands of years, and no manure was likely to have been applied in the past, any more than the present. Mr. Bourne doubts whether the Canadians and Americans should use the term "city" so freely. He must bear in mind that they do not use an English standard. For that matter, towns and villages are much smaller in Ireland than in England. In a country of sparse population a city or town is regarded, not for its population, but for the attributes of civilisation it provides. and the weary traveller is glad to get to a town of three shanties, in any fresh region of the world. There the local people find a store and an artisan, a monthly market, and a yearly fair. A dozen houses may become an important centre, and

many a town noted in ancient geography or the Middle Ages had only a population of two or three hundred. In relation to its local surroundings, Chicago was great a generation ago, before it became a metropolis. There is an observation to be made as to customs duties in Canada, Australia, &c. These are not possessed by New York, Minnesota, Oregon, or California. To the Federal Government belong the federal or imperial revenues, from public lands, customs, excise, post-office, supreme court, &c., and consequently each State has to provide for its local and parochial expenditure, as in England, by local taxation. The abandonment of federal revenues to the Dominion of Canada has caused anomalies, and no comparison can be made with the neighbouring States. One point not mentioned with regard to Manitoba, was the prospect of the working of the Hudson's Bay Railway and route, which may have a material effect on the North-West. In his boyhood, intercourse with Hudson's Bay, Mr. Clarke stated, was more familiar in London than it now is here, or even in Winnipeg.

NINTH ORDINARY MEETING.

Wednesday, February 4, 1885; The Earl BROWNLOW in the chair.

The following candidates were proposed for election as members of the Society:—

Bhownaggree, Mancherjee Merwanjee, 107, Warwick-road, W.
Hughes, Prof. D. E., F.R.S., 108, Great Portland-street, W.
Julian, Robert Hill, 1, Roseneath-villas, Military-road, Cork.
Kraftmuir, Edward A. H., 11 A, Albany, Piccadlliy, W.
Marks, Thomas T., Stratford-villa, Llandudno.
Paxman, James, Hill-house, Colchester.
Takhtsingjee, The Maharajah, K.C.S.I., Bhavnagar.
Thomson, James Hall, Newstead, Perry-vale, Forest-hill, S.E.

The following candidates were balloted for and duly elected members of the Society:—

Donkin, W. F., Malvern-lodge, 97, Upper Tulse-hill, S.W.
Dunn, Alexander Douglas, 19, Charterhouse-square, E.C.
Evans, Frederick Evans, Postal Telegraphs, Birmingham.
Lavender, John, 11, Todd-street, Manchester.
Lavender, John, jun., 201, Bury New-road, Manchester.
Morison, Arthur Duff, 23, Regency-street, Westminster, S.W.
Salt, Shirley Harris, M.A., 73, Queensborough-terrace, W.

The paper read was—

EDUCATION IN INDUSTRIAL ART.

By CHARLES G. LELAND.

It is greatly to be regretted when people are—like the late Thomas Carlyle—so sensitive to the shams of life or of society, as to be deliriously unhappy. To the Sage of Chelsea, sham was a synonym for despair; therefore he was compared by an American reviewer to a man leaning over the bottomless pit, and shouting down to the unhappy dwellers therein, "Ye 're a' domned!" And yet true intellectual or moral progress means the putting away of shams, and the only question is whether this shall be effected by anarchy or gradual reform.

There is no branch of human knowledge in which so much old-fashioned sham survives as in writing or talking about art. There are few men who can discuss it without going into ineffable spasms and æsthetic raptures; It is a stage through which all must pass; unfortunately, there are very few who know it. Having devoted myself in my youth, forty years ago, to æsthetics and the history of art under Thiersch, of Munich, and others, I passed betimes through the mediæval measles, and the "hallowing influences of beauty" whooping-cough. These "too-too utterly-utter" disorders had not then reached England, much less America. Now, we may see sufferers from them all about us—even the tradesmen are at times touched with them in their circulars; and not long ago in Philadelphia, I heard that our black cook had said that "Mr. Jones the grocer sold berry æsthetic hams."

The cure for this sham is to be found in a varied knowledge of arts, and in practical education. Raphael, Albert Dürer, Cellini, Michael Angelo, were the results (not the causes) of a state of society in which every workman was capable of executing decorative designs, and even of making them. Now the world has taken from the ineffable æsthetic transcendentalists, firstly, the idea that "art" in the main means only the making of pictures and statues; and, secondly, that unless a child manifests an innate talent or born gift for art, it should not be expected to study it. There are children who have a genius for art, but of these there is not more than 1 in 10,000 or 15,000. Among more than 1,000 pupils who were under my teaching in the Public Art School in Philadelphia, there was only one who had any genius whatever for art—but, on the other hand, there was not a single girl or boy who passed into the second year of in-

struction, who could not design a pattern, and then execute it in embroidery, or wood, clay, sheet-metal, leather, mosaic, or other material. I have found, by full experience and hard work, that every child in every school may, by a certain and very simple method of training, be made into an artisan. From this point he may become either a practical mechanic or an artist. It is the proper preparation for either. As easy embroidery is the best beginning to lead little girls up to prosaic plain sewing, so the boy who begins with design and modelling and carving, makes not only the best shoemaker, or smith, or carpenter, in less than the usual time, but also a better sailor, or farmer, or miner, or collier. For there is no calling in life in which developed quickness of perception and constructiveness is not a great power. For years I studied my pupils and the results of their studies so assiduously, that I learned from them more than I taught—there was not one who was not more my teacher than I was his. For my school was strictly an experiment; and the first of its kind in which the great object was to ascertain, by a very extensive trial, on a large scale, of what children were really capable. Thus, as I said, I found—and herein the highest authorities in education in America agree with me—that decorative art was the first best step towards more practical work. Secondly, it seemed to be as fully proved that many, or perhaps all, could by this system become creditable, yes, true artists. By attracting attention, as Maudsley has shown, interest and will may be awakened, and so an average pupil may be gradually led to produce better work than is given by a badly taught genius. There is only one person in thousands who has, in a high degree, a sense of colour and its affinities. Yet there are few or none who cannot attain to this by proper training. "There are," says Hamerton in his "Life of Turner," "hundreds of old pictures, often by famous men, which are popularly supposed to be works in colour, but which, in reality, are nothing but simple monochromes in grey or brown, with a little colour here and there to prevent them from being avowed monochromes. By means of this artifice, a painter who does not feel that he has much colouring power, may gradually work his way from monochrome to real colour." I beg you to observe that what Mr. Hamerton says of colour is as applicable to all branches of art-industry, and that there is a simple and easy method by which from a right beginning one may progress so far as to even develop to a very high degree, by attention, interest, and industry, that taste which is supposed to be inseparable from innate genius.

It was many years ago, during my former residence in England, that I began to seriously study the problem of manual industry as a branch of all education. It occurred to me that as games awoke in all children quickness of perception, so the exercise of the constructive faculty developed in the young powers apparently but little allied to it. I call attention to this because I was destined, years after, to test and prove it by much experiment.

In the very beginning of my reflection on this subject, I was much struck by the fact that no hard or prosaic employment, no trades, in fact, could with success be taught to young children of both sexes. The speculations of Amos Comnenius and Ratkei, the practical efforts of Pestalozzi and Fellenberg, and in later days of Biedermann, of Leipsig, Georgens, Schwab, and others, only proved, as Carl Werner has shown, that children may be taught, according to their age and strength, a certain amount of mechanical or household work, which was, indeed, no great discovery. All over the world, efforts to teach boys under fourteen years of age a trade have not succeeded, because neither muscles nor brains are sufficiently developed at that age for a child to do a man's task. It occurred to me that what was wanting was a system by which, from a very easy and attractive beginning, both girls and boys could be prepared for all kinds of work whatever. I saw that it was a mistake to teach a trade directly, but that a child might be so trained as to take up any kind of handwork readily and intelligently, so as to learn a trade sooner than it would otherwise have done. This system I eventually found in teaching children the minor or decorative arts, the preparation for these being a simple method of outline decorative design, such as forms the principle of all coherent ornament in all ages and in all countries.

The principle, in short, on which I would base instruction is, that a child not as yet capable of learning a trade or a serious or severe branch of industry can, however, easily master all branches of decorative art, and that these form a fit introduction to more practical work. This is my whole theory, and I beg you to impress it on your memories. It is very strictly according to the principles of evolution. As the flower precedes the fruit,

so we have seen in the past that the prehistoric dwellers of Europe, who are supposed to have corresponded closely to the Esquimaux and Chukches of the present day, could draw and carve with skill long before they had learned the use of metals. Great proficiency in art, as in poetry, preceded mechanism and prose. Mankind was then in its infancy; it gave its creative energy to what amused it, and gratified its instinctive love of ornament and of art. Even mules become delighted with, and are very proud of, their ornaments. Children represent primæval man. They also love to make anything which is within their capacity. You all know that to mere infants, a box of paints, a transparent glass slate for drawing, and to boys, boxes of tools are most acceptable gifts. The basis for this faculty is the instinct for constructiveness. And as it seeks for artistic employment in its early stage, I firmly believe that those who begin in childhood with art, will, in the end, prove to be the most intelligent, practical mechanics.

Egypt, which was in ancient days the mother of learning, proved to be strangely enough in this case also my instructor, for it was in Miss Whately's school in Cairo that, on seeing two very little girls executing each one side of the same piece of elegant embroidery, that it flashed upon me that if mere babes could execute such art-work, that this must be the kind of hand-labour with which to begin in schools. Truly we never know in this world to what our good works may lead, and as little I deem did Miss Whately ever imagine that from her classes a correlative idea would go forth which could result in the establishment of hundreds of schools in America and Great Britain. That it did so, I will show you in the course of this address.

The next day I found in the bazaars numbers of young of both sexes executing embroidery from memory, inlaying, *repoussé*, and even jewellery, with a degree of skill which in Europe no one expects save from grown up and highly trained artists. I reflected, or observed, that all over the East, and in Southern Europe, South Germany, and the Tyrol, mere children execute art work of many kinds, especially wood-carving, with so much skill that it has a market value, without its preventing them from attending school. For it is a law which I cannot explain, that there is hardly any kind of work into which art or ornament enters, which is not relatively easy or agreeable, while all the minor arts are extremely so.

Returning to England, I made a few successful experiments in education, and published, through Messrs. Macmillan, a small work on the minor arts, in which I suggested that classes for studying them might be formed in every village, or in its school. The hint was taken by Mrs. Jebb, of Ellesmere, who at once established a school in which design and wood-carving were taught, and entered into correspondence with me. The result of her experiment was the gradual establishment of a great number of similar schools, united in what is called the Home Arts and Industries Association; a title which very inadequately represents the scope and excellence of the work which it is affecting. Of this I will speak anon. Returning to America, I laid my theory of industrial art education before the School Board of my native city, Philadelphia. I found the members of this body men of great common-sense, allied to a perfect willingness to impartially consider reforms in education. They had under their control in the public schools 115,000 pupils, so that there was no want of children wherewith to begin. I frankly assured them that what I proposed to do was to conduct an experiment on a hitherto untried system, the object of which was to ascertain what kind of hand-work or manual industry was best suited to children who are from ten to fourteen years of age. I did not speak of infants, since there are in Philadelphia a number of Kinder-garten in which elementary drawing and modelling are well taught. Nor did I propose to interfere with the functions of the technological, or, as they are correctly termed in America, industrial schools. I say "correctly," because it is a great mistake to associate industry and work with punishment and suffering. I had much trouble for a long time, both as regarded the press and the public, who persisted in regarding my school as an effort to teach useless and frivolous fancy work to children who had better be employed at something practical. It was continually suggested to me that what was needed was to teach boys trades, or such mechanical work as would fit them to become good mechanics, and that this was already being done at a large and excellent institute of our city. It was in vain that I remarked that the authorities in that very institute had admitted that they did not care to take pupils under fourteen years of age, and that those of a still larger industrial school in another city had even published a statement to that effect. And it was also in vain that I long protested

that industrial education is far more needed for girls than for boys. The latter, if industrious, generally get on with or without schooling, there are so many callings open to them. For girls these are so few, that one may say of many that they have almost no resource. I had also to point out that an industrial school, if well appointed, cost about £20,000, and could only be established in a large city, whereas, by the system which I proposed, whatever work which was best suited to children's capacities could be taught in every school in the country. To this the principal of a prominent technological school opposed a vermilion edict, in which he declared that there could be no greater wisdom than teaching in such schools as his own, and no greater foolishness than attempting to introduce industrial art or hand-work to all schools.

I was given a suite of large, well-lighted rooms, properly furnished, an ample appropriation, and began with 150 children, which number was soon increased to 200. There were two classes of 100 in each, the first of which attended on Tuesday afternoons, and the second on Thursdays. Every one of the public grammar schools had the privilege of sending two or more pupils. This privilege was very greatly prized, both by the children and their parents. In one school of eighty-four pupils, every one recorded an application to be allowed to attend the art classes. For in the first place, the work was simply an absorbing and delightful amusement, and in the second, many obtained pocket money by selling its results. When I had first made cold hammered *repoussé* brass-work fashionable, it brought high prices, and one of my pupils, a schoolboy just seventeen, actually made 218 dollars, or over £40, by it, during the two months of his summer holiday. I must admit that this was due more to his enterprise as a "salesman" than to his skill as an artist, since I have had much younger scholars who far surpassed him in design, in lining, and in attaining high and perfect relief. And I may say, by the way, that, in this school, mere cold-hammering on wood subsequently attained a depth and perfection which skilled artists and professional chasers admitted, with astonishment, had never been equalled save by annealing, and on the pitch.

Instruction was given in drawing, modelling in clay, embroidery, and wood-carving. To these were soon added colouring the clay with glaze; pottery, or throwing with the wheel, which was, however, far beyond the strength of most of the boys; and wood-carving. To these I soon added mosaic setting, executing patterns for carpets in chequers; sheet metal work on Saturday afternoons; simple decorative oil painting and china on the glaze, of a monochromatic character; with carpentry, turning, inlaying, and fret-sawing. The wood-work, with the exception of the carving, was under the charge of a clever man of colour. But it would give, after all, a very inadequate idea of what was learned in the school should I merely read the list of the branches taught. It was not till I had been teaching for some time that I found, by designing patterns which could be executed in every branch of decorative art, that there was a fundamental principle, common to all, and that even the child who mastered it could, after attaining practical proficiency in modelling, very easily acquire, often in one or two lessons, not one, or a few, but all minor arts whatever. This principle lay in a simple system of outline design, and of teaching the children from the first lesson design instead of copying. This system, which I set forth on the black board at the last meet- of the Social Science Congress, at Birmingham, was, I am happy to say, warmly approved of by those present. I soon published it in a little manual, and it has been adopted in hundreds of schools in America.

A propos of this principle, allow me to relate an anecdote. A lady who carried on, with her sister, an art school in another city, visited ours. At the end, one remarked to the other, "Why, we teach everything that Mr. Leland teaches, except the carpentry and design." "Excuse me," I said, "but you and I teach nothing in common. You have a certain number of branches; I teach but a single art, and that is the art of making a design, and of working it out in any material whatever." I knew nothing of this system of design when I began to teach, and it was with a feeling akin to awe and terror that I realised that if I had not discovered it, all my plans for industrial education would have come to naught.

I had, during four years, about one thousand children pass through the school. Many remained only a few weeks, but all who passed into a second year, or had from fifty to sixty lessons, learned enough to make a living, or to very readily obtain situations. I never had a single pupil who did not like the work as much as if it were play; that is to say, I never had one who was incapable of becoming an artist. The children were drawn from all classes in society—some from the poorest—but the girls

were all ladylike, and the boys perfectly well-behaved. On one occasion only, I was obliged to dismiss three girls for impertinence; with this single exception, all went well. The parents of these children were of varied nationalities—American, British, German, and Jews. I always had a few coloured pupils. In proportion to their number, I found that quadroon girls were my cleverest scholars; yet they, like the Jews, attained proficiency mainly by steady plodding.

There was one boy, and one only, of whom I despaired. He seemed to be so incorrigibly stupid at every kind of work, that I several times ordered him to leave the school, but just as often his round stolid little face reappeared at the next lesson. My niece, Miss Robins, who kindly aided me in carrying on the school, interceded for him. So he remained and plodded and persevered. He was, at fourteen years of age, a real proficient in wood-carving and *repoussé*. There are, I am aware, artists and connoisseurs in such work here present. I beg leave to call their attention to two panels, for which this little boy first made the designs without copying, and then modelled them in clay before carving them in wood. Secondly, I show you a specimen of his cold-hammered brass *repoussé* work. We have had, however, far more elegant and elaborate specimens of the latter, as for instance large chimney-pieces, plaques, and lunettes. During the last week previous to my leaving I paid one boy, aged fourteen, more than £3 for an order in brass, which he had executed during ten days, and that while he was going to school and keeping up a high average in his studies. Let me remark that the prices paid for *repoussé* work to order, and for wood panels, are about the same in America as in London. When we received orders, we always executed for them an original design. There were thirty children in the wood-carving class, three of them coloured, and there was not one who could not have earned nearly £2 a week. One of these, a dark mulatto, actually obtained a paid situation in a wood-carving factory.

Now, I must inform you, that this art work instead of proving an additional burden to the over-crowded school course, actually lightened it. It is a difficult matter to make work hard to those who like it. I was much troubled at first by the schools sending me their cleverest pupils; I made very earnest instance, that I should have only those of average capacity. I am sure that I got them. The most intolerable child to teach is some little prig, whom some lady has picked out as being gifted with a genius for art, on the strength of his having executed some rubbishy rubbings in lead pencil of robbers and cows. Quite unknown to me, the School Board inquired of the teachers in the public schools what was their opinion of the effect of the art school on the usual studies. And it was the unanimous opinion of all the teachers that such children as had attended the Industrial Art School had manifested an increased quickness of perception and developed a greater intelligence than those who had not. And I think that, on reflection, you will all admit that this was to be expected. Take one boy and teach him, though superficially, what is meant by Gothic, Greek, or Moorish decoration, let him learn to carve, model, and inlay it, and do you not suppose that he will have developed more cleverness than one who has not? I have had not one, but several girls of fourteen, who could design from their heads Moorish patterns of pure elegance and correctness, and then execute them in stamped leather. I have known one who had thoroughly learned this, to execute in one afternoon the seat of a chair which sold for £1, the leather costing 2s.

When a pupil came, he or she was obliged for some time to take lessons in designing patterns. When some proficiency in this was attained, the scholar was set to model on alternate days in clay. After modelling for a time anything was allowed. Seeing others no cleverer than themselves executing a great variety of work, they all knew that they had only to try to do the same.

Hitherto, or to a certain point, this school was simply a successful experiment, as were Mrs. Jebb's Home Arts Classes. But it finally attracted the attention of the general government, that is to say, of General John Eaton, who was at the head of the Bureau of Education, Department of the Interior, Washington. He requested me to write a pamphlet, setting forth my system, and the method by which it might be introduced to schools and families, or taken up by individuals, the apparatus or materials requisite, and this was published as Circular No. 4, 1882. Any of my hearers who are interested in this subject may obtain for themselves and friends as many copies of it as they want, gratis and postpaid, by sending a list of names and addresses to General Eaton, and by stating that it is at my request. It is usual to print only 15,000 of these pamphlets, but if more are asked for

they are supplied. My hearers may judge of the interest which this work awakened, by the fact that 60,000 copies had been circulated. The result was the establishment of literally hundreds of schools and classes, and for nearly three years I have received letters by every mail, asking for further information on the subject. Thus, as I write these lines, the last mail brought me two, informing me that the study of the minor arts on my system had been introduced to two important schools. It had been taken up with great success in the principal lunatic asylum and reformatory school in Philadelphia, and I have recently been informed that the United States Prison Reform Association hope to make it general, they having begun by making it a part of the studies in the celebrated Elmira Penitentiary School. A lady in New York, Mrs. William Blodgett, established a great number of associated schools or classes for poor children, the teachers being sent to me for instruction. I should mention that I had during the past year in the school, a number of grown-up lady scholars, who had been sent by School Boards or other associations, to qualify themselves to become teachers. Of these, four were from Ohio, four from the State of New York, and others had come even from South Carolina.

Certain details may be of interest. We had no rent to pay, as we occupied the upper story of a large public school building. After the furniture had been provided, the annual expense for every pupil was about £1 a head. I made no charge for my services, and my two principal assistants, for a long time, also worked for nothing. I found that it would be perfectly possible, by employing an agent to solicit orders, and to sell goods, to meet all current expenses, by disposing of the children's work. I am happy to say that the School Board wisely and generously opposed this, the chairman of the Committee on Art, Mr. William Gulager, declaring that "whatever was worth teaching, was worth paying for." I will here, however, call your attention to a fact not generally thought of. In a school like this, everything can be executed which is necessary to not only ornament, but, to a degree, furnish a house. Very elegant articles of furniture, such as chairs, and chests finely carved, were designed and completely executed by the children. They made handsome chimney-pieces of carved wood, *repoussé* brass, and mosaic. We could furnish stencilling for walls; the girls once embroidered a magnificent *portière*, 6 ft. by 6 in. It is easier to weave rag carpet in one colour, and then ornament it by running tape in it, than to do these, and it will last a century. Sixty per cent. of all the money invested in the houses of England has been strictly for ornament. I doubt if there be any staple industry which involves so much capital as decoration. It may be inferred from this what money may be made by orders. Let it be also remembered that in such work every article can be as easily made from an original design as a duplicate. Now, the day is not far off when originality, or uniqueness, coupled to hand-work, will be regarded as essential to decorative art work. This was the real secret of the excellence of all the ornament in the world before the days of machinery and labour-saving processes. One could write a lecture or an interesting book on this subject alone.

It is possible that very few present are aware of the high quality of such work as can be executed by children. There was not in the Health Exhibition anything made by young people approaching in excellence the ornament made by my pupils. I began by exacting that what they made should be good, considering that it was made by minors. I ended by obtaining such work as is generally made by grown-up artisans, or, indeed, far better work as regards design.

While this was going on in America, the same work was being quietly, yet wisely and effectively, carried out in England by a different system, and it is to this that I would especially call your attention, and bespeak in it your warmest interest. I refer to the Home Arts Association. In a little pamphlet recently published, Mrs. Jebb, of Ellesmere, states that it is the outcome of a movement begun quietly in a country district some years ago. Acting on a suggestion contained in the preface to "The Minor Arts," by myself, a few amateurs opened Saturday classes for teaching artistic handicrafts to working boys and men. As the success of the experiment became assured and evident, the number of classes increased both in England and Ireland, and new ones were formed in towns as well as villages. Some of these were conducted by amateurs, in others professional aid was given. In some instances the classes became rapidly self-supporting. The cost of establishing them is small. If there be a lady or gentleman who knows something of drawing, it is not difficult to teach a class the rudiments of any easy art by the aid of a simple manual. To help these

classes, I published in America a series of twelve hand-books on such subjects as design, wood-carving, modelling, embroidery, stencilling, papier-maché, painting, and leather work. It is found that in England £3 is sufficient to cover the initial outlay for a wood-carving class of six boys, if a voluntary teacher be provided with a room. A similar class for *repoussé* work in brass only requires an outlay of £1 10s.; a class for clay-modelling even less. The work of the pupils, if properly conducted, can always be sold for enough to cover expenses; but here I would remark that this should be always made for special orders, and that it is a very bad plan to try to sell the manufactured wares. The latter floods the market with charity fair work, the former exacts a far higher standard of excellence.

From these English schools, one class holder writes of the taming and humanising effect of the lessons on wild boys. This has been observed to be very great in the reformatory schools and lunatic asylums in America.

Parents have in many instances testified, both in my own country and in England, to the degree in which the absorbing influences of art study kept children quiet and happy.

This year a pupil carried off the second prize for panel carving at the Dublin Exhibition of Amateur Decorative Art. One of my own pupils in England, a young lady who had very little instruction indeed, took two prizes within the first year for the same kind of work. A bronze medal was awarded to the Association at the Health Exhibition for work shown there.

This union has only of late began work in earnest. Though it has been growing for years, it is but a few weeks since it held its first general meeting. It proposes to supply detailed information to all members who wish to teach or learn such minor arts and industries as can be practised at home; also to lend good designs and models, and circulate manuals and other works on industrial and art education. It is also intended to establish a central normal school, where amateurs and teachers may be taught the principles of design, with its working out in all the minor arts. Those who desire to open classes on the plan pursued by the association, may obtain full information by addressing the secretary, Miss Dymes, at No. 18, Wimpole-street, London.

I would call attention to the fact that "this association affords help, which is practically unconditional to small beginnings, and to isolated workers in remote districts, and that in a way which is not and cannot be done by more important official existing organisations." It is able to develop in the most obscure small villages, germs of talent which could not otherwise be reached. I am sure that no one who will closely and impartially examine this one system, will deny that if industrial classes are instituted by private exertion, aided by an association, the local interest will be far greater than if the matter were introduced in a purely official manner. The art taught by private effort alone would be often irregular and feeble, but this is corrected by the higher influence of the association.

A great impetus to the reform inaugurated by the association has been given by the voluntary movement of Mr. Walter Besant, by which the culture and wealth of the upper classes has been brought to bear on the lives and work of the people. In it we have the same idea, working in a different direction. I would also commend the establishment of ladies' decorative art clubs. There is one of these in every city, and, I may say, almost every small town, in America. That of Philadelphia, which was established by me, and of which I am president, consists of 200 ladies, who pursue the same branches as those taught in the school, but with more effort towards the fine arts. It is to be desired that such unions could exist here. They possess all the advantages of a school and club combined, and are more liked than either separately could be At present, it is literally true that, though the facilities for art study are not in America one-fourth of what they are in England, there are probably four times as many girls in a hundred studying art there as there are here.

To render the practical utility of the Home Arts Association perfectly clear, I would state that any ladies or gentlemen knowing of any boy or girl, or young woman, whom they would like to have trained in practical arts, with a certainty of being fitted for some kind of employment, can do so by forming a small club, or by personally incurring the slight expense requisite to send the applicant to our classes. Again, we have now printed, and shall soon circulate, as useful a work as was ever issued. This is the so-called leaflets, or brief instructions in separate pamphlets of a very few pages, teaching the rudiments of the minor arts. My experience warrants my saying that an extensive dissemination of these would give extraordinary stimulus to the arts in this country. The only drawback to a general culture of art, is the extreme ignorance of the vast majority of all people, both old and young,

of what they are capable. With these leaflets will also be issued designs to aid and guide all art students and workmen. I suggested, three years ago, to the American Board of Education, that it should disseminate, gratis, art patterns and short pamphlets of instruction, or leaflets, and General Eaton warmly approved of the idea, but it was not carried out. In this respect we are here in advance.

Trusting that what I have said has not been without interest to you, I conclude, hoping that it will awaken a much greater interest in the truly charitable, and, in the ancient cultured sense, humane institution, which is so worthily represented here by the chairman and by many of the officers of the Home Arts and Industries Association.

DISCUSSION.

The Chairman, in inviting discussion, said he had been much struck with the great readiness with which this scheme had been taken up in America by the Government departments, and he feared it would be much longer before the Government departments in England would introduce industrial art teaching in primary schools; the Home Arts and Industries Association would, therefore, probably have to carry on its amateur work much longer than Mr. Leland's association did. He said he did not encourage the sale of work unless orders had been previously received, but in England he thought it would be very difficult to obtain orders beforehand, and he should like to know what steps were taken to procure orders.

Mr. Leland said he did not take any steps, but the public found out what was going on, and he was often written to for specimens. He did not encourage the sale of work, because it made the boys quite wild with money getting, when they found they were paid for what they did. A large quantity of work was accumulated, but they were constantly applied to, not only by private individuals, but also by other schools for specimens. He had no doubt any quantity of orders could be obtained by employing a traveller, for there were plenty of people who wanted art work done.

Mr. Gilbert Redgrave said he had listened with great pleasure to this paper. Mr. Leland did not come forward with a new and untried scheme, for though he spoke of the work in America as an experiment, it was quite clear from the statistics that the movement had already taken a great hold on the people, and achieved a wonderful success considering the time it had been in operation. At the present time we seemed at the threshold of a great change of view with regard to education, there being a great tendency in all educated countries to revert to what had been spoken of as the manual element. To a great extent the education of old times had been of this character, but as civilisation advanced, there had been a tendency to lose sight of that, and go in simply for brain work. Now the question seemed to be how far, even in relation to brain work, might we with advantage revert to the manual education of the past. All would admit that there was a great deal of benefit to be derived from this double training, and some of the ablest exponents of education had shown that nothing was so well fitted to develop the brain of the infant as the training of Froebel and the Kinder-garten system. That kind of work had now to be carried on to the earlier periods of primary education. There were difficulties in the way, the school buildings not being constructed with a view to it, and many educationalists objected, but still a partial solution had been arrived at. A certain amount of this training had been introduced into schools in France, in Germany, and even in England. In some of the Board schools in Manchester, children were being taught to work in wood and use carpenters' tools. Mr. Leland had warned them against attempting to teach children trades, and said that the teaching of design was something quite different. They should also beware of making the money element too prominent, for it would never do to encourage the idea that children would obtain considerable sums of money for the work done in school. He had heard a good deal of the work done by Mrs. Jebb in what she called recreation classes, which were established for poor children and working men in the evenings. The success attained had been most remarkable, and he was satisfied that the Home Arts and Industries Association had a great work before it.

Mr. Oakley Coles thought this movement was especially interesting in connection with the cries of distress which were heard from various parts of the country; the inability to obtain employment; the necessity of emigration, and the utter incapacity of many of those who emigrated to do almost anything for themselves. This manual education might easily be made subservient to training children in those branches of work which would enable them to help themselves if they were put down in an uncultivated part of the world. The average agricultural labourer was quite incompetent to mend a chair, or put a hinge on a door if required, or do any rough piece of metal work; but the object of this Association was to teach boys the elements of such operations, so that, if occasion required, they might be able to turn that technical knowledge to account. Besides this, there was an aspect of the question which made it of great, political importance, inasmuch as it brought the two extremes of society into intimate contact. Instead of the people living in the shadow of the great house, they would live in the light of it; all the choice things and beautiful objects of art might be made available for teaching the children, and the most

valued possessions of the nobility and gentry might be brought within reach of the intelligence of the children in the villages, thus breaking down class distinctions and prejudices, and introducing in the teaching of art that true kinship between classes which was essential to all national progress. At the present moment, when there were movements at work in all directions tending to break up society, anything which had for its object to bind society together must commend itself to the vast majority of the nation; and on this account alone the work of the Association was worthy of all sympathy and support. He did not think that in this country the same prices would be obtained for this work as in America, for there was already so much machine work that it would be difficult to supplant it by handicraft productions. But, on the other hand, there were many signs of a return to the desire to possess work which should be stamped with the individuality of the maker, and that one should no longer go from one house to another and recognise the same patterns everywhere. This was a minor point, but if each man's house were not only his castle, but were stamped with his own individuality being built up by himself, there would be more scope for handicraft work, and an enormous benefit would be conferred on all classes of society.

Dr. PHILIP MAGNUS expressed his warm sympathy with this movement, but had little to add to what had been said by Mr. Redgrave. He agreed with him that the element of manual work had not hitherto been introduced into schools to so great an extent as was desirable, and no one sympathised more with the movement for making it an essential part of elementary education. He had no great belief in the cry which was being raised about over-pressure in schools; but if anything were calculated to lessen the effects of over-pressure from mental exercise, it would be by giving the children some manual exercise as well. Apart from that, he was quite at one with Mr. Leland when he claimed that educational advantages arose from handicraft teaching. As he had justly said, the object was not to teach any particular trade, but that the teaching should be of a disciplinary and educational value; that it should have for its object the training of a sense which had been almost entirely neglected hitherto. The hand was a most important organ of perception, and when it acted in sympathy with the eye, considerable results could be obtained. Up to the present, the education given to children who were to be artisans had been almost entirely of a literary character, but he hoped the time was not far distant when some manual instruction would be considered, not a mere optional addition, but a necessary part of the instruction given under the code. Not being an artist, he spoke with great diffidence on any subject connected with art, but he should like to know how far it was possible to teach design to children who had not already some knowledge of drawing. Until recently, very little had been done in the way of teaching design, even in the art schools, but greater efforts were now being made in that direction, together with instruction in the history of ornament and other matters connected therewith. Drawing itself was taught to a much less extent than was desirable, for though the London School Board set a good example by insisting on its being taught in all schools, this was not the case generally throughout the country, and in villages, where it was particularly necessary that these art industries should be taught, and to which it seemed to him that drawing was a necessary preliminary. Modelling might also be taught, and it was a subject in which children always took an interest. Mr. Redgrave had referred to the fact that art industries were taught in many schools on the Continent, and this was particularly the case in Austria, but in all these cases the general education of the child was carried on at the same time, and he received very sound instruction in drawing. With regard to the remuneration which this kind of work obtained in the United States, though they could not but appreciate the specimens which had been handed round, he thought the work must be of a better class before it would be saleable to any great extent in this country. It was very important that children should aim high, not so much to receive immediate remuneration as to learn the principles of art, which they might afterwards apply to the industries by which they obtained their livelihood. There was much room for this kind of work in villages, and it would tend greatly to assist the rural population. There was a fairly good school of this kind in Pulborough, and another at Petworth, and in many of these places some amount of profit was derived from it.

Dr. HEINEMANN said he could not help thinking that the remarks of some of the previous speakers were capable of a still wider application than they had given them. They had mostly confined their attention to national and Board schools, but he went much farther, and maintained that drawing ought to be taught in every school of whatever character. There was no school in Prussia, or any other part of Germany, in which drawing did nor form a necessary part of the curriculum. That had not been realised in this country, and even where drawing, music, and painting were taught in ladies' schools, the results were often very unsatisfactory. He believed the plan proposed by Mr. Leland would do great good if introduced into every school, but the question arose whether it were possible to do so. The question of over-pressure had been alluded to, and he believed it did exist to some extent, though it had been much exaggerated, and the best means to prevent or counteract it would be the universal introduction of the system recommended by Mr. Leland. It was quite possible, for it was already done in some parts of Germany. Take, for instance, the village of Oberammergau, which had

become famous on account of the "Passion" play performed there; it consisted of about 800 inhabitants, and every one was artistically inclined, and all the children did exactly what Mr. Leland wished all the children in America and England to do.

Mr. E. ABLETT said it might be interesting to the meeting to know the progress which had been made in art teaching in the London Board schools, which for two years he had had the honour of superintending. Drawing was not an item in the code, and did not stand on the same footing as reading, writing, and arithmetic, consequently where the master had a liking for it, it was tolerably well taught, but in others it was very much neglected. Soon after he was appointed, he went to Paris, to see what was being done there, and he found that the majority of elementary schools were provided with a special room in which drawing was taught, provided with appropriate furniture, and good casts, and a specially qualified teacher attended at certain hours. He thought perhaps the London School Board would do something of the same kind, and he had been trying for nearly three years to have a number of rooms set apart for this purpose; six months ago he succeeded in getting one room in a school at Saffron-hill, and to it they drew the most talented boys from the adjacent schools one afternoon a week. A highly qualified teacher was employed, and not only drawing, but designing and modelling in clay had been attempted with great success. He hoped if the Board were satisfied with the results, that similar centres might be established elsewhere. One great difficulty was to find teachers who were not only well up in art, but were also capable of managing a large class of small children. To meet that difficulty, they were trying to train teachers in the evening, and he hoped in time these teachers would be qualified to take charge of art classes. He did not think it would be possible to have a first-rate art class in every school at present, but it would be quite possible to teach some drawing, particularly of a geometrical character; and such drawing might well be made a compulsory portion of the curriculum. The higher kinds of drawing could only be taught by specially qualified teachers. He had also been engaged in trying to improve the drawing in the schools belonging to the Girls' Public Day Schools Company. It was found that the work there was not of a very satisfying character, principally because attention had been paid too exclusively to freehand and outline drawing. A somewhat elaborate system had now been introduced, by which they led up from freehand and outline drawing from the flat, to the treatment of ornamental forms, flowers, model drawing, shading, painting, and designing. No very high standard was reached as yet, but the object was to keep the pupils interested. He hoped this would lead to the development of drawing in middle-class schools, so that many would take up the work of the Home Arts and Industries Association.

Mr. G. C. HAITE remarked that much of what Mr. Leland had said depended upon what was understood by designing. Covering a piece of paper or wood with ornament was not designing. It was quite possible to teach drawing and painting, or modelling, but designing could not be taught, though it might be directed. From the experience of many years, he had found that most students who came to schools of art lacked the one essential to design—originality. They all wished to be landscape or figure painters, and seemed to forget that ornamentation, or design, was an art of no mean kind. He did not recognise what were called the minor arts; there was no such thing as a minor art. Metal work, wood-carving, and book-binding, were as worthy of the name of art as painting or sculpture. He sympathised entirely with Mr. Leland's efforts, and could not help being struck with the results he had shown, which were certainly surprising as regarded mechanism and skill; but the question was were these young people taught to become artists, or were they taught art as children were taught reading and writing, so that they might understand poetry, but not with the idea that they would all become poets or authors. It was quite right to teach all children to appreciate art, but if they were taught with the idea that all could become artists as a profession, he thought it was a great mistake. The gift of creation did not come from training or man's aid. He had had painful experience of men who offered to work for him at 15s. or 30s. a week, really clever men, but who had mistaken their vocation; they were not designers, though as skilled workmen they would have been very valuable. Many professional men found the greatest difficulty in getting any assistance at all in real designing. He hoped Mr. Leland would not think he was opposed to his scheme, with which he greatly sympathised, but he could not help fearing that much of his labour was misdirected.

Mr. KRALL said he had had many boys under him who had not the least idea of shape or drawing; and he believed the great cause why so many were unemployed was their want of technical education. Numbers of men were out of work because they had no understanding of what art was; whilst on the other hand numbers of employers would gladly employ men who had such knowledge, if they could find them. In nearly all continental countries boys were obliged to attend classes in the evenings, where they were taught modelling, drawing, carving, or something of the kind, and consequently, when they left school, they had much better ideas of shape and outline than if they had not had such instruction. Many of the boys under his care scarcely knew what to do with their time in the evenings, and art classes would be of immense benefit to them. Again, ladies and the public generally would learn to appreciate much better beautiful objects of art workmanship, if by some personal training they understood

what labour and time were necessary to their production.

Mr. LELAND, in reply to the point made by one speaker that such objects as he had spoken of commanded higher prices in America than in England, said he recently asked the price of a pair of brass bellows, machine-made, and very ugly, and learned it was forty shillings. His boys would have been glad to supply a much better article for less money. As regards wood-carving, he had shown two panels representing the ordinary work of the school; they sold for six shillings in the United States, and he did not think he could get them for less in England; probably if he gave an order he should have to pay more. But he did not encourage the sale of work or getting orders; what he wanted was that the children should learn to use their hands, and the experiment he made was with the view of seeing what kind of work was best suited to them. He found that boys were not strong enough to use a jack plane or saw, or even to throw pottery on a wheel. He knew pretty well what was going on in French technical schools, a few years ago at any rate, and it was generally too hard for boys under fourteen. This kind of work was given to children, not because it was art work, but because they learned to design, and familiarised themselves to the use of tools; and this was the best preparation for any kind of art work whatever. Between the Kinder-garten and the industrial or technical school there was an interval which was not filled up at present properly in any country, and that interval required work of an artistic character. The boy who had learned to model ever so little, would not go and get higher wages than a workman, but he would be preferred as an apprentice, and would probably get higher wages than a boy without that training. There was a great demand for boys who had something more than a merely literary education. Girls also, more readily obtained situations, and even if they did not possess it, would claim to have a superior knowledge of patterns and designs, if they had studied in an art school, and the claim was generally conceded. Art did not teach a trade, but it familiarised the hand and brain with work. He knew a prisoner in Philadelphia who was a clever artist, and he learned to make shoes, and elegant shoes too, in so short a time that all the authorities of the jail were astonished at it. He had not the slightest doubt that many of the gentlemen present would learn to make shoes in a time which would astonish any shoemaker if they thought it worth while to try. He could not thoroughly explain in a few minutes his system of teaching design, though he had explained it at Birmingham last summer. Briefly, he would say that the decorative art-work of the world, or a vast proportion of it, might be reduced to a few very simple principles; he meant where it was coherent—the best portion of it. Excluding Japanese and Chinese work, it might nearly all be reduced to what might be called the organic development. Mr. Ruskin, and Mr. Lloyd, of South Kensington, spoke of it as the principle of the vine; not that all ornament consisted of vines, but of a trunk with circular and spiral curves, with external and internal tangential curves springing from them; from that you obtained a construction line which was absolutely perfect, and to this and allied forms nearly all the decorative art in the world might be reduced. These fundamental lines were easily learned, and the pupils soon learned to add crockets, finials, and anything else which was necessary. Drawing and designing were learned together, and many of the designs produced by his pupils would pass muster anywhere. He much preferred a child who was utterly ignorant of the matter than one who had been taught designing or drawing in the chaotic incoherent manner which generally prevailed.

The CHAIRMAN, in proposing a vote of thanks to Mr. Leland, said there could be no doubt of late years art had made gigantic strides in America. Even in the highest walks of art, amongst the finest sculptors to be found in Rome, were Mr Storey and Miss Hosmer; and in the best American magazines were to be found specimens of wood engraving showing an amount of perfection which was perhaps hardly equalled in the world. He was sure they would all wish Mr. Leland God-speed in the gigantic philanthropic enterprise he had undertaken.

The vote of thanks was carried unanimously, and the meeting adjourned.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

Arrangements are now in progress, by which it is hoped that the whole of the garden illuminations this year will be carried out by means of the electric light. It is intended to employ for this purpose 10,500 incandescent lamps, most of which will be of five-candle power, though some will be equal to ten, and some to twenty candles; the aggregate will amount to 52,000 candles. This is exclusive of the lighting of the fountains, which will be on much the same scale as last year, and of the interior illumination, to which there will be considerable additions, in consequence of the increased area of buildings to be lighted. The garden illuminations will be carried out by Messrs. Siemens Bros., while the lighting of the buildings will, as before, be divided amongst the principal electric lighting firms.

THE MANUFACTURE OF BUTTER AND CHEESE IN LOMBARDY.

The dairy industry, in the Milanese district,* dates back from the most remote periods. Plutarch and other ancient writers speak of that region as being important for pasturage. The irrigated meadows of Lombardy have been famous for ages, and Virgil, in the line—

"Claudite jam rivos; sat prata biberunt,"

alludes to the water meadows in the valley of the Po.

Amongst the ancient writers, Pliny was the first to mention cheese, and whilst praising that sent to Rome from Nimes, alludes to the cheese made in the valley of the Po as being sour. The first mention of butter, is made in Plutarch's life of Caius Cæsar, when at a banquet given in honour of the great captain at the house of Valerius by the Milanese chieftans, asparagus cooked in butter was served up.

It was not until the close of the middle ages that the cheeses of Parma and Lodi became famous. The production of milk and butter, however, was neglected for several centuries, and the breeding of horses took the place of that of cattle in the Lombard plains; and Milan was for a long period celebrated not only for armour, but also for supplying the best and fleetest steeds for warfare.

Later on, the production of wool from the numerous flocks that pastured in the plains rose to great importance, and it is calculated that 70,000 persons were engaged in the dyeing and weaving of wool in the city of Milan; and that 4,000 pieces of cloth were exported annually.

The woollen trade, however, fell into decline in consequence of competition from other countries, and the breeding of sheep finally yielded place to that of cattle, and the dairy industry gradually rose to importance. Gallo, of Brescia, writing in 1550, states that cheese was sold at that time at 10 marks the *peso*, equal to about 3 centimes per kil. (0·135d. per lb.), therefore, the value of milk at that date could not have exceeded 40 centimes per 100 litres (0·18d. per gallon). At the present time, the price of milk averages 14 lire per hectolitre, about 6⅓d. per gallon.

The most important product of the Lombard dairies is the *grana*, better known in England as Parmesan or Lodian cheese, and of all the varieties of cheese made this is the most profitable, as it can be kept for a long time, improving with age both in quality and value. Its manufacture being also limited to a certain district, it is not subject to competition, and whilst the qualities of cheese such as the gruyère, battelmatt, ementhal, brienz, &c., can be made almost anywhere, the production of grana beyond the limits of the district where it is manufactured, has invariably proved unsuccessful. This favoured district comprises the territory of Lodi, and many places in the province of Pavia, on the left bank of the Po, whilst on the right the production of grana cheese extends to the provinces of Parma and Reggio.

The manufacture of this description of cheese is not altogether free from risk, and being still carried on entirely by rule of thumb, scientific principles have not as yet been turned to account in its production; the process of manufacture have been handed down from generation to generation, and all depends upon the skill of the *casaro*, as the person is termed to whom the making of cheese is entrusted.

Five different classes of persons are interested in the production of cheese:—

1st. The landlord or owner of the farm, which usually is let to a tenant.

2nd. The farmer or tenant who cultivates the land.

3rd. The owner of the cows (mandriano), as itis not always that the cattle belong to the farmer.

4th. The dairyman (lattaro). In some cases the manufacture of butter and cheese is carried on by the owner of the cows, but more usually by another person called the lattaro, who purchases from the mandriano all the milk produced, at a fixed price, and stipulated by a yearly contract commencing from the 24th April (St. George's-day). This price includes the use of buildings and utensils for making cheese, the pigstyes, and for a certain quantity of firewood to be supplied.

5th. The merchant, who at the end of the season purchases the whole of the cheese produced either from the farmer or from the dairyman as the case may be. The cheese is stored in warehouses (casere) for two or three years before it is sold in order to ripen, after which it is either sold direct to the consumer or to other merchants who export it.

Although the method adopted for the making of cheese is invariably the same throughout the year, two different qualities are produced, which vary according to the season, that manufactured from the 24th April to the end of September being called *maggenga*, whilst the cheese produced from October to the 24th April is termed *invernenga*. The first differs from the second insomuch as, during the hot weather, it is necessary to heat the milk before all the cream has had time to rise to the surface, whilst during the winter, as it will keep sweet for many hours longer, it is allowed to stand until all the cream can be separated, and in consequence, the cheese made during the summer is richer than that produced in the winter. The milk obtained from the cows in the evening and morning following, is put into shallow copper pans, not more than eight inches in depth, placed in specially constructed buildings well sheltered from the changes of temperature. The cream rises to the surface, and is separated from the milk, which is then taken to the casone, as the place where the cheese is made is termed. The length of time that it is allowed to remain in the shallow pans varies according to the season of the year, being shorter in the summer than in the winter.

* Taken from a pamphlet entitled "L'industria del latte nell Agro Milanese," by Edoardo Guscetti.

The milk separated from the cream is next put into large bell-shaped coppers of sufficient size to contain all the milk produced during the day, and in some cases, these vessels are large enough to contain 220 gallons. The copper is suspended by a chain from a light crane, to facilitate its being placed over or removed from the fire, which is made on a hearth constructed in the floor. The copper is exposed to a slow heat, until the milk reaches a temperature of about 28° R. (95 Fahr.), being stirred up all the time with a wooden instrument called the rotella. Rennet is then added in proportions that vary according to the time of year, the stirring operation being continued in order that it shall be thoroughly mixed with the milk, and as soon as the process of curdling is completed, the mass is beaten with another implement, called the spino, in order to break up the flakes into minute granular particles. The copper is again put on the fire, the heat being so regulated that the whey has time to separate from the curds previous to reaching a temperature of from 40° R. to 42° R. (122° to 127° F.). During that operation, which is technically called the *tempo della cottura* or *spurgo*, and which occupies from half-an-hour to an hour, according to the season, the colouring matter is added.

This operation being completed, the copper is then removed from the fire, and the mass of curds which have settled down to the bottom are put into a coarse hempen cloth, locally called patta, and the cheese so formed is next put into a wooden vat, in which it is slightly pressed for about 15 minutes in the summer, and 25 minutes in the winter, in order to squeeze out the greater part of the whey. It is next put into a wooden mould called the fassera, which is tightened up with a rope, and afterwards compressed with a circular piece of board called tondello, on a sloping table, so that the whey may more readily run off. The cheese which, by that time, has reached a certain consistency is now taking to the salting-house (salatoio), where it is sprinkled on every side with salt for 40 days, during which period it is kept perfectly clean and well greased.

Such is the process adopted at the present time, and which has been handed down from generation to generation, and which has as yet received but little aid from science, with the exception, perhaps, in fixing and measuring the temperature, and in determining, by means of chemical analysis, the exact point at which the milk passes from the alcaline to the acid state.

The author, who has devoted attention to the manufacture of cheese, has come to the conclusion that the best form in which rennet should be used is that in powder, and with regard to the colouring, he now uses a liquid specially manufactured for that purpose in Denmark, and which is also prepared at the government establishment at Lodi. It has been hitherto supposed that saffron, which is also used, besides acting as a colouring agent, had an astringent effect, and was therefore necessary in order to produce a good quality, which, however, has been found not to be the case, and although the cheese may be of a good colour when first cut, it rapidly changes to a greenish yellow when exposed to the air.

By boiling the whey that remains after the grana cheese is made, another product, the fiorito, is obtained; then, by adding some whey that has turned sour, ricotta or mascherpa is made, and the refuse furnishes the scotta, which is used for fattening pigs. The two first products are usually consumed by the farm labourers on the spot as soon as made.

The seasoning of the grana cheese is also an important branch of business. The producer (if not at the same time a merchant), as soon as the cheeses are made, sells them, and they are taken to the casere, as large warehouses built for the purpose are called; here they are ranged in order upon shelves, and are kept clean, the crust grated from time to time, and anointed with linseed oil every third day, and turned in order that the liquid contained in them may be distributed uniformly throughout the mass, and in this manner are allowed to season for two or three years.

Some of the warehouses in the outskirts of Milan contain as many as 6,000 cheeses, of the value of £16,000 to £20,000, and it is estimated that the total value of this article in the warehouses near Milan amounts to from £720,000 to £800,000.

The grana is one of the most wholesome of cheeses, and can be kept a very long time. One of the principal advantages in the manufacture of this kind of cheese is that the whole of the cream is available for the making of butter.

It is here unnecessary to describe the manufacture of butter, as the process is, more or less, the same in every country, but, at the present time, from the care taken in its production, the Milanese butter can compete advantageously with the best brands of either France, Switzerland, or Holland.

Two qualities, the salt and the fresh butter, are exported; the first being sent in large quantities to Constantinople, Turkey in Asia, Africa, and even Brazil, whilst the fresh finds a good market in the south of France, Paris, and London. At the present time, thanks to the excellent railway service, butter made in Milan on the Tuesday, is sold the following Friday in the market at Paris. Every 100 cows produce, on the average, from 9 to 10 hectolitres (176 gals. to 198 gals.) of milk per day, and with that quantity a cheese weighing 50 kils. (110·23 lbs.) is made, as well as 20 kils. (44·09 lbs.) of butter, and with the residue not consumed by the farm labourers from sixty to eighty pigs are fed.

A considerable quantity of the butter made in Lombardy is sent to Charenton, where it is mixed and moulded into other shapes, and sold as the best French butter. It is estimated that twelve tons of butter are sent away weekly from the Milan railway-station.

It is only during the last half of the present century that the stracchino of Gorgonzola has come into repute; formerly this cheese was considered to be quite of

secondary importance. Its manufacture originated in the following manner:—As soon as the first cold weather in the autumn compelled the herds or bergamine* to leave the summer Alpine pastures for those in the plains, and it being impossible during the journey to make the cheese in the way just described, the milk, when still warm from the cows, was curdled and hung in cloths from the cart of the herdsman, each successive milking being added, so that at the end of the journey the cheese so produced was salted, and called stracchino, which name originated from the fact of the milk from which it was made being furnished by the cows (in the Milanese dialect *stracche*) tired from the journey. As the first halt in the plains was usually made at Gorgonzola, the cheese was called *stracchino* of Gorgonzola. In the course of time, and in order to meet the increased demand for this cheese, it became an article of special production instead of a makeshift as at first, and its manufacture has now extended not only all over Lombardy, but even to the district of the Lomellina in Piedmont. Of late years, in consequence of the facilities of communication, it has found a market in foreign countries, and large quantities of Gorgonzola are annually exported. The process of the manufacture of this cheese differs but slightly from that just described.

Inside these cheeses, and especially those made during the journey down from the mountains, are found greenish marks, vulgarly termed *erborine;* these are due to a kind of mould *(Penicellum glaucum)*. For foreign markets, and especially for England, cheese with these marks are greatly in demand; and the author having observed the fact of this mould resembling that of the Roquefort cheese, undertook a journey to France for the purpose of learning the process, and examining the caverns where these cheeses are stored. The mould in the Roquefort cheese appears to be due to two causes; first, the artificial introduction of the germs of the *Penicellum glaucum;* these germs are obtained by making a bread of wheat and barley flour, with vinegar and strong yeast, which is baked for a long while, and then allowed to become mouldy, and afterwards ground into a fine powder, which is mixed with the curds. Another reason is the particularity of those grottoes, which are natural cavities in the rocks, damp and airy.

The experiments respecting the artificial production of the mould in the Gorgonzola cheeses, however, did not give satisfactory results; but the storing of them in the natural grottoes of the Valsassina was attended with success, and the author is now convinced of the advisability of storing these cheeses in the numerous natural cellars that can be found in the Valtellina, &c.

After the manufacture of the Gorgonzola is over for the season—that is to say, in November—another quality of rich cheese, called *crescenza*, is made in the provinces of Milan and Pavia. It is soft, and slightly acid in flavour, and lately has become an article of considerable importance, as it can now be sent all over Europe by parcels post. This quality is now known in commerce as the *stracchini* of Milan, and the author, in November and December of last year, exported forty-five tons.

* The name of bergamine was originally given by the Lombards to those herds that came down into the plains in the winter from the Alps near Bergamo, and which title now comprise all herds of cattle.

Obituary.

Sidney Gilchrist Thomas.—Mr. Thomas, one of the inventors of the basic process for the production of steel and iron from phosphoric pig iron, died at Paris on Sunday, 1st inst. In 1878, as a result of extensive previous experiments, he submitted to the Iron and Steel Institute a paper "On the Elimination of Phosphorus," in which he announced his discovery, conjointly with his friend and relative, Mr. Gilchrist, of a process whereby phosphorus could be eliminated from the charge in the Bessemer converter, and the most impure ores of iron thereby adapted for the manufacture of steel. In recognition of his distinguished services to the metallurgy of iron and steel, Mr. Thomas was presented by the Iron and Steel Institute with the Bessemer gold medal. On April 27th, 1882, Messrs. Thomas and Gilchrist read a paper on their process before the Applied Chemistry and Physics Section of the Society of Arts, and for this paper a Society's medal was awarded them by the Council. For the benefit of his health, Mr. Thomas spent the winter of 1882-3 in Algiers, whence he travelled to Paris a few months ago, to become much worse, until his death on Sunday morning last, at the early age of 36.

General Notes.

The Health Exhibition Surplus. — The Council of the International Health Exhibition, at a meeting held, under the presidency of Sir James Paget, in the Rooms of the Society of Arts, received the statement of accounts, from which it appeared that there would probably be a surplus of £19,000. Inasmuch, however, as this was but the second of the series of Exhibitions announced by the Prince of Wales at the close of the Fisheries Exhibition, it was decided that the surplus should not be disposed of until the financial success of the forthcoming Inventions Exhibition should be assured.

PROPOSED FELL RAILWAY OVER THE MONGINEVRO.—The project for a railway on the Fell system between Oulx and Briançon has recently been laid before the Italian Minister of Public Works. It is proposed that this line should commence at the station of Oulx (47 miles from Turin) on the line from Turin to Modane, and crossing the torrent Dora Riparia, to follow the course of this torrent on its right bank as far as Cesana, then the line would again cross the Dora, and then following the national road over the Monginevro pass, would descend at La Vachetta to Briançon. The total length of the proposed line is 19½ miles, of which 11½ miles will be on Italian territory and 8 miles on French. The total difference of level to be overcome in the crossing of this pass is 2,422·77 feet. The maximum gradient will be 7 in 100 (1 in 14·28), and this on the Italian side for a distance of a little more than 3½ miles. The permanent way will consist of steel rails, weighing 70 lbs. per yard, fixed to ordinary cross sleepers, and on these sleepers in the middle of the track will be bolted a longitudinal one carrying the central rail, which will weigh 80 lbs. per yard. This line, if approved of, will be a most important one for Turin, as it will shorten the distance to Marseilles considerably.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

FEBRUARY 11.—"Report of the Royal Commission on Metropolitan Sewage." By Captain DOUGLAS GALTON, C.B., F.R.S. Sir FREDERICK ABEL, C.B., D.C.L., Chairman of Council, will preside.

FEBRUARY 18.—"Malt-making." By H. STOPES.

FEBRUARY 25.—"Past and Present Methods of Supplying Steam Boilers with Water." By W. D. SCOTT MONCRIEFF, M.Inst.C.E.

MARCH 4.—"The Evolution of Machines." By Professor H. S. HELE SHAW.

MARCH 11.—"The Rivers Pollution Bill." By J. W. WILLIS-BUND.

Papers for reading at subsequent meetings:—

"The History and Manufacture of Playing Cards." By GEORGE CLULOW.

"The Musical Scales of Various Nations." By A. J. ELLIS, B.A., F.R.S.

"A Marine Laboratory as a Means of Improving Sea Fisheries." Professor E. RAY LANKESTER, M.A., F.R.S.

"Recent Improvements in Coast Signals." By Sir J. N. DOUGLASS.

"The American Oil and Gas-fields." By Professor JAMES DEWAR, F.R.S.

"Exploration and the best Outfit for such Work." By General W. FIELDING.

"The Growth of Sugar Beets in England." By Colonel Sir F. BOLTON.

INDIAN SECTION.

Friday evenings at Eight o'clock.

FEBRUARY 20.—"The Teak Forests of India and the East, and our British Imports of Teak." By P. L. SIMMONDS. Colonel MICHAEL, C.S.I., will preside.

MARCH 6.—"The Trade between India and the East Coast of Africa." By FREDERIC HOLMWOOD, British Consul at Zanzibar.

MARCH 13.—"The Present Condition and Future Prospects of Female Education in India." By MANCHERJEE M. BHOWNAGGREE, late Secretary of the Alexandra Girls' English Institution, Bombay.

APRIL 17.—"The Parsis and the Trade of Western India." By JEHANGEER DOSABHOY FRAMJEE.

MAY 8.—"The Ancient and Modern Methods of Treating Epidemics of Small-pox in India." By ROBERT PRINGLE, late Sanitary Department H.M. Bengal Army.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings at Eight o'clock.

FEBRUARY 24.—"The Spanish Gold-fields and the Mines of Rio Sil." By WILLIAM SOWERBY.

MARCH 17.—"The Congo and the Conference, in reference to Commercial Geography." By Commander CAMERON, R.N., C.B.

MARCH 31.—"Kiliman'jaro and the Surrounding District of Equatorial Africa." By H. H. JOHNSTON.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings at Eight o'clock.

FEBRUARY 12.—"Production of Ammonia from the Nitrogen of Minerals." By GEORGE BEILBY.

FEBRUARY 26.—"Tempered Glass." By Dr. FREDERICK SIEMENS.

MARCH 12.—"Recent Improvements in Photographic Development." By W. K. BURTON.

APRIL 23.—"The Chemistry of Ensilage." By FREDERICK J. LLOYDD.

The dates given above are subject to alteration.

CANTOR LECTURES.

Monday Evenings at Eight o'clock.

The Third Course will be on "The Distribution of Electricity." By Professor GEORGE FORBES, M.A., F.R.S.E.

LECTURE II. Feb. 9.—Five systems of distribution: (1) multiple arc; (2) series; (3) multiple arc series; (4) accumulators; (5) secondary generators. —Systems for multiple arc distribution: (1) parallel line; (2) parallel reversed line; (3) tree mains; (4) independent wire mains; (5) network mains.—Importance of using high potential lamps.—Massive mains *versus* independent wire mains.—Considerations as to size of districts.

LECTURE III. Feb. 16.—Series mains.—Multiple arc series.—Methods which have been used.—Modifications proposed.—Economy of this system.—Supposed danger of high potentials.—Three wire system.—Accumulators used in two ways: (1) charge and discharge in series; (2) charge in series, dis-

charge separately.—Secondary generators.—Example of central station lighting now accomplished.—The problem an engineering problem with all the data for calculation.—Conclusion.

The Fourth Course, "Chemistry of Pigments." By J. M. THOMSON, F.R.S.E., F.C.S., Lecturer on Chemistry at King's College, London.

February 23, March 2.

The Fifth Course, "Carving and Furniture." By J. HUNGERFORD POLLEN.

March 9, 16, 23, and 30.

The Sixth Course, "Photography and the Spectroscope." By Captain C. W. DE W. ABNEY, R.E., F.R.S.

April 20 and 27.

The Seventh and concluding Course, "The Manufacture of Toilet Soaps." By C. R. ALDER WRIGHT, D.Sc., F.R.S., F.C.S.

May 4, 11, and 18.

ADMISSION TO MEETINGS.

Members have the right of attending all the Society's meetings and lectures. Special tickets are required for the Juvenile Lectures. Every member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the members, but admission can also be obtained on the personal introduction of a member.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 9...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. George Forbes, "The Distribution of Electricity." (Lecture II.)

Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. H. Robinson, "Some Recent Phases of the Sewage Question."

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. S. B. J. Skertchly, "The Geology of the London Suburbs."

TUESDAY, FEB. 10...Royal Institution, Albemarle-street, W., 3 p.m. Prof. Moseley, "Colonial Animals, their Structure and Life Histories." (Lecture V.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on Mr. David Salmond Smart's paper, "The Modern Practice in the Construction of Steam-boilers." 2. Mr. B. Baker, "The Metropolitan and Metropolitan District Railways." 3. Mr. J. W. Barry, "The City Lines and Extensions of the Metropolitan and District Railways."

Photographic, 5a, Pall-mall East, S.W. 8 p.m. Annual Meeting.

Anthropological, 3, Hanover-square, W., 8 p.m. Mr. H. H. Johnston, "The People of East Equatorial Africa."

Colonial Inst., Westminster-palace Hotel, S.W., 8 p.m. Mr. Arthur Clayden, "New Zealand in 1884."

WEDNESDAY, FEB. 11...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Captain Douglas Galton, "Report of the Royal Commission on Metropolitan Sewage."

Geological, Burlington-house, W., 8 p.m. 1. Prof. J. W. Judd, "The Tertiary and Older Peridotites of Scotland." 2. Mr. T. Mellard Reade, "Boulders wedged in the Falls of the Cynfael, Ffestiniog." 3. Arther W. Walters, "Chilostomatous Bryozoa from Aldinga and the River Murray Cliffs, South Australia."

Microscopical, King's College, W.C., 8 p.m. "The Life History of a Septic Organism, hitherto unrecorded." (Presidential Address—illustrated by lantern microscope.)

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

Parkes Museum of Hygiene, 74A, Margaret-street 8 p.m. Dr. Percy Frankland, "The Selection of Water for Domestic Supply."

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. B. Haughton, "Indian Railway Network," 1884.

THURSDAY, FEB. 12...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Chemical and Physical Section.) Mr. George Beilby, "Production of Ammonia from the Nitrogen of Minerals."

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Sir John Lubbock, "Leaves."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. G. C. Haite, "Wall Paper and their Manufacture."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, "The New Chemistry." (Lecture V.)

Telegraph-Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. 1. Capt. H. R. Sankey, "Some Experiments in Electrotyping with a Dynamo-Electric Machine." 2. Mr. Illius A. Timmis, "The Working of Railway Signals and Points by Electro-Magnets."

Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, FEB. 13...United Service Inst., Whitehall-yard, 3 p.m. Lieut.-Col. Commandant J. H. Macdonald, "The Change required in the Field Exercise for Infantry."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Sir John Lubbock, "The Forms of Leaves."

Astronomical, Burlington-house, W., 3 p.m. Annual General Meeting.

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. Gilbert Hunter, "The Maybole Waterworks."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

New Shakspere, University College, W.C., 8 p.m. Miss Grace Latham, "Shakespere's Use of the Extra Syllable and Run-on Line."

SATURDAY, FEB. 14...Froebel Society, (at the HOUSE OF THE SOCIETY OF ARTS) 7 p.m. Annual Meeting.

Physical, Science Schools, South Kensington, S.W., 3 p.m. Annual General Meeting.

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Mr. G. J. Stoney, "The Scale in which Nature works, and the Character of some of her Operations." (Lecture II.)

Journal of the Society of Arts.

No 1,682. Vol. XXXIII.

FRIDAY, FEBRUARY 13, 1885.

All communications for the Society should be addressed to Secretary, John-street, Adelphi, London, W.C.

NOTICES.

PATENT LAW.

The Council have determined to hold, during the time the International Inventions Exhibition is open, a Conference on Patent-law. The subjects for discussion will include the working of the new Patent Act, and also questions of International Patent-law.

Further particulars will be announced later on.

PRACTICAL EXAMINATION IN VOCAL AND INSTRUMENTAL MUSIC.

The next Examination in London will be held by Mr. W. A Barrett, Mus.Bac. (Oxon.), at the House of the Society of Arts, 18, John-street, Adelphi, W.C., during the week commencing 8th June, 1885.

Full particulars can be obtained on application to the Secretary.

CANTOR LECTURES.

Professor George Forbes delivered the second lecture of his course on "The Distribution of Electricity," on Monday evening, 9th inst. He described different systems of distribution, and devoted special attention to the "tree main" and "network main" systems of multiple arc distribution. He showed, by a plan of a city divided into squares, how the current might most economically be distributed, and laid stress on the point that, in the case of the distributing boxes, every such box should be nearer to the main than any lamp which it supplies.

These lectures will be published in the *Journal* during the summer recess.

SOCIETY OF ARTS' PRIZES.

The Council of the Society of Arts are prepared to award the following Gold Medals in connection with the International Inventions Exhibition:—

John Stock Prize.

Under the John Stock Trust, one Gold Medal, for the best application of Photography to a Permanent Printing Process, Group XXVI., Class 140; Group XXIX., Class 159.

Howard Prizes.

Under the Howard Trust, five Gold Medals, for the best exhibits (coming within the terms of the Trust*) in the following Classes:—One for the best exhibit in Group IV., "Prime Movers," Class 26. Steam-engines and Boilers. One for the best exhibit in Group IV., Class 27. Gas and Air Engines. One for the best exhibit in Group IV., Class 28. Means of Utilising Natural Forces. One for the best exhibit in Group XI., Classes 59 to 62. One for the best exhibit in Group XIII., "Electricity," Class 72. Distribution and Utilisation of Power.

Fothergill Prize.

Under the Fothergill Trust, one Gold Medal for the most novel and best exhibit in Group XXVIII., "Philosophical Instruments and Apparatus," Classes 148 to 158.

Alfred Davis Prize.

Under the Alfred Davis Trust, three Gold Medals to be awarded in Division II. of the Exhibition (Music), Groups XXXII. to XXXIV., Classes 166 to 180.

The Council propose to ask the Juries in each Class to recommend for their consideration either two or three exhibits which they might consider deserving a prize. It will not be necessary for any special application to be made in respect of these Prizes.

A full list of the contents of the classes referred to above was given in the *Journal* of January 9th.

* The Trust was left "for the purpose of presenting periodically a prize or medal to the author of a treatise on the properties of steam generally, or any of them particularly, as applied to motive-power, or it may be of air or permanent gases, or vapours, or other agents so applied, or to the inventor of some new and valuable process relating thereto."

Proceedings of the Society.

TENTH ORDINARY MEETING.

Wednesday, February 11, 1885; Sir Robert Rawlinson, C.B., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Best, Charles William, 18, Abingdon-street, Westminster, S.W.
Gordon, John, 10, Holland-park-gardens, W.
Horton, Alfred E., 104, Manor-road, Brockley, S.E.
King, Bolton, 28, Commercial-street, E.
Moffatt, George, 29, Eastbourne-terrace, W.
Petheram, Frederick Wm., 2, Lombard-court, E.C.
Ravenshear, Albert Francis, 11, Spencer-road, Herne-hill, S.E.
Redwood, Boverton, F.C.S., 85, Gracechurch-st., E.C.
Smallman, Henry, 5, Hammerton-crescent, Brixton-rise, S.W.
Swan, Joseph W., Lauriston, Bromley, Kent.

The following candidates were balloted for and duly elected members of the Society:—

Boucneau, Adolphe Joseph Henry, 48, Warren-street, Fitzroy-square, W.
Boustead, John, 34, Craven-street, Strand, W.C.
Fraser, Robert Alexander, 2, Russell-chambers, Bloomsbury, W.C.
Michael, Colonel, C.S.I., Bangor-lodge, Ascot.
Rhodes, John George, Oakdene, Brackley-road, Beckenham, Kent.
Robson, Frederick, Young Men's Christian Association, Mill-lane, Stockton-on-Tees.
Wingfield, Charles Humphrey, 26, Upham-park-road, Chiswick.

And as an Honorary Corresponding Member.

Mueller, Baron Sir Ferdinand von, K.C.M.G., Ph.D., F.R.S., Melbourne, Victoria.

The paper read was—

REPORT OF THE ROYAL COMMISSION ON METROPOLITAN SEWAGE.

By Captain Douglas Galton, C.B., F.R.S.

The disposal of the London sewage has been a burning question for the metropolis during the greater part of the last forty years, and it will be convenient in the first place to give a brief historical summary of the various proceedings which have taken place. The present state of the question is principally due to what may be termed the hap-hazard way in which the metropolitan drainage system came into existence. The main metropolitan sewers were originally the streams and brooks which conveyed the water of the higher levels direct to the river; these were the Fleet, the Ranelagh, the Falcon brook, the Effra, &c., &c. There were, moreover, in the low-lying lands of the metropolitan area, which were under high-water level, cuts, or channels, for drainage, which were guarded by sluices in the river bank, to be opened at low water, to allow of the passage of upland water, and closed on the rising of the tide. These cuts, sluices, and brooks, were under the jurisdiction of various local bodies, termed Commissioners of Sewers. As houses spread over the ground between the streams, brooks, and cuts, the natural water-supply diminished, and they became the outlets for the refuse water of the population. The drains from side streets were turned into them; they were gradually covered in, upon no systematic plan; so long as the refuse water passed away out of sight, it did not seem to matter what happened to it. These covered sewers occasionally became choked with deposit, and had to be cleaned out, which seems to have given rise to the idea that sewers should be of sufficient size to be entered by a man for the purpose of cleansing; the idea of a self-cleansing sewer did not prevail in those days. Before the introduction of water-closets, fœcal matter was received in cesspools, which were emptied periodically; but when water-closets were introduced, an overflow from the cesspool was carried into the sewer, and subsequently the water-closets were discharged directly into the drain. When it passed to the Thames, the wide foreshores of which lay in the heart of the metropolis, it formed banks of black, fœtid mud, containing considerable quantities of organic matter of a most putrescent kind. Alternately immersed in water and exposed to the action of air, which, in consequence of its porous condition, it absorbed in large proportion, this mud united all the conditions favourable for the most active putrefactive fermentation, evolving not only gaseous emanations, but diffusing also a large amount of putrescible soluble matter through the river, which supplied additional material to the process of decomposition which was going on in the water itself.

These various evils, taken in connection with the defective construction of the sewers, resulted in producing serious dangers to health. The Metropolitan Sanitary Commission, of which Mr. Edwin Chadwick was a prominent

member, was appointed in 1846, and reported in 1848. They recommended a revision of the drainage system of the metropolis, and enunciated the view that the rainfall should be separated from the sewage proper, the rainfall being carried direct to the river, in the old brook courses, and that the drains should be made on new lines, and of a size which would ensure a sufficiency of sewage in the drain to cause an adequate velocity of flow, so as to prevent stagnation and deposit. They further recommended the consolidation of the various authorities which dealt with sewers and with roads under one jurisdiction. Other reports from the General Board of Health recommended that the water-supply of the metropolis should similarly be placed under one authority, so that the supply might be more effectually regulated and controlled, both in quality and quantity. These all pointed to the vast importance of creating a united government for London.

The report of the Metropolitan Sanitary Commission led to the consolidation, under the Metropolitan Commissioners of Sewers, of the jurisdiction exercised up to that time by eight separate Commissions of Sewers, but the sewers in the City of London remained under the jurisdiction of the City authorities. Upon this new body devolved the duty of devising a scheme of drainage. In the first place, they obtained that the Ordnance Department should make a survey of London on the scale of five feet to the mile. They did not adopt the views of the Royal Commission as to the separation of sewage from rainfall, but the engineer to the new Commission, Mr. Frank Forster, laid down certain principles of design, and proceeded to prepare plans for intercepting the sewage from the upper districts, and conveying it to the river direct, so as to prevent the flooding of the low-lying districts. He also proposed to intercept the sewage from the Thames within the metropolis, and convey it to points lower down the river. He appears to have completed a design for dealing with the sewage on both sides of the river, but in the long discussions which ensued, his health failed, and he retired, and died. His successor was Mr. (now Sir Joseph) Bazalgette, who was charged by the Commission with the duty of preparing, in conjunction with Mr. Haywood, engineer to the Commissioners of Sewers for the City of London, a plan for dealing with the sewage of London north of the Thames. In 1855, however, the Metropolis Local Management Act was passed. This Act vested in the Metropolitan Board of Works all the main sewers which at that time were under the jurisdiction either of the Commissioners of Sewers for the City of London, or of the Metropolitan Commissioners of Sewers; but the district sewers were placed under the management of the Vestries, and thus there was no single authority to whom was committed the duty of controlling the whole system of drainage of the metropolis.

The Act went on to enact as follows :—

"Such Board shall make such sewers and works as they may think necessary for preventing all or any part of the sewage within the metropolis from flowing or passing into the river in or near the metropolis, and shall cause such sewers and works to be completed on or before the 31st day of December, 1860."

It was then further enacted that—

"Before Metropolitan Board of Works commence any sewers and works for preventing the sewage from passing into the Thames as aforesaid, the plans of the intended sewers and works, together with an estimate of the cost of carrying the same into execution, shall be submitted to the First Commissioner of Her Majesty's Works and Public Buildings, and no such plan shall be carried into effect until the same has received the approval of the said Commissioner."

It is unnecessary here to follow the detailed proceedings which took place upon this new arrangement; they are given in the "Report of the Royal Commission on Metropolitan Sewage Discharge." It will suffice to state generally that the Metropolitan Board appointed Sir Joseph Bazalgette as their engineer, and that plans were at once prepared.

The main principles upon which the design was based were—(1) the acceptance of the existing state of things involving the removal of sewage combined with a proportion of rainfall, and the rejection of the suggested separation of sewage from rainfall, which would have entailed the consequent construction of a new system of sewers of limited size; (2) the retention of the brook courses as main sewers; (3) the protection, by means of a new system of intercepting sewers, of the low-lying districts from the sewage of the upland districts; (4) the removal of the sewage from the Thames within the metropolitan area, and its conveyance to parts of the Thames outside and below that area.

The main sewers followed generally the lines of the sewers now executed. They were proposed to terminate, on the north side of the Thames, in an outfall at Barking Creek, and on the south side, in an outfall in the Plum-

stead Marshes. The cost was estimated at £2,300,000. When these plans were submitted to Sir Benjamin Hall, then First Commissioner of Her Majesty's Works and Public Buildings, he referred the question of outfall to Captain Burstal, R.N., who reported that the northern outfall should be removed lower down the river, at least as far as Rainham Creek, and that the southern outfall should be placed in Erith Reach. The plans were subsequently submitted to three referees, to report their views generally on the proposed main drainage of the metropolis, and on the points of outfall. The referees were—Mr. James Simpson, engineer to the Chelsea and Lambeth Water Companies, now dead; Mr. Blackwell, engineer to the Kennet and Avon Navigation, also dead; and Captain Douglas Galton, the author of this paper.

The referees agreed generally with the principles upon which Sir Joseph Bazalgette's scheme proceeded; that is to say, they agreed that a separation of the sewage and rainfall would not be expedient in the case of the metropolitan sewage; that the question of chemical deodorisation, or of utilisation of the sewage on land, would, under the circumstances, present very great difficulties, and entail a heavier expense than a properly considered scheme for turning the sewage into the Thames at a fitting outfall. But they did not concur in the manner in which these principles were proposed to be carried into effect by the scheme of the Metropolitan Board of Works. Their objections may be summed up as follows :—

1. The scheme did not sufficiently provide for the future; the population of the metropolis in 1851 was about 2,400,000; it has increased regularly by one-fifth in every ten years since the beginning of the century, and in 1881 it amounted to nearly 4,000,000; in 1901, at this rate of increase, the population will amount to about 6,000,000. The scheme of the Metropolitan Board only provided for a prospective population of 3,255,000, and the referees objected that, on that account, and on account of the limited provision it made for the removal of rainfall, the sewers would frequently overflow into the Thames, and that the low-lying districts would be liable to be flooded.

2. That the scheme of the Metropolitan Board would remove by complete gravitation the drainage of only 27 square miles, out of 118 square miles, to the outfalls at Barking and Plumstead, and the drainage of 31 square miles would be lifted once, and the drainage of 43½ square miles would be lifted twice, whereas, by constructing the tidal channels for the removal of the sewage as suggested by the referees, all the sewage which would flow to a point five feet above Trinity high water mark near the metropolitan boundary, that is to say, the drainage from 81 square miles of the metropolitan area could have been removed by gravitation to Sea Reach.

3. That the proposal to turn the metropolitan sewage into the Thames, near Barking, or even at the outfalls in Erith Reach, suggested by Captain Burstal, would not prevent the sewage from returning within the metropolitan limits, and would be injurious to the eastern districts of the metropolis which lie adjacent to the Thames, the population of which was rapidly extending.

4. The referees consequently proposed that the sewage should be taken to a point on the north side of the Thames between Mucking Lighthouse and Thames Haven; and on the south side to Higham Creek in the Lower Hope, because the strength of the current at both of these places is sufficient to prevent any deposit of materials brought down by the sewage; and the great expanse of water, the continual accession of clean tidal water, and the rapidity of current would ensure the mixing of the sewage with water under the most favourable circumstances, and at a point where the shores were almost uninhabited. The referees added that these were the only places in the river, either above or below, which entirely fulfil the conditions essential to the object in view.

5. The referees were not, however, satisfied with the removal of the sewage to a point lower down the river, but contemplated uniting with the removal a form of purification. Instead, however, of deodorisation by chemicals, they proposed the principle of partial purification by dilution and movement during the flow of the sewage through the outfall channels for a distance of nearly twenty miles. To effect this, they proposed that there should be added to the sewage, at the head of the outfall channel, a volume of water direct from the Thames, at high water, equal to six times the then estimated dry weather flow of the sewage.

6. The referees estimated the total cost of the intercepting and collecting sewers within the metropolis, and of the outfall channels, at £5,438,000, of which about £2,250,000 was the cost of the outfall channels.

Upon this report of the referees, the

Government declined to sanction the plans of the Metropolitan Board of Works; a long correspondence ensued, and during the discussion the Liberal Government then in office was succeeded by a Conservative Government, and Lord John Manners became First Commissioner of Her Majesty's Works. The new Government passed an Act of Parliament, in 1858, relieving the Metropolitan Board of Works from the necessity of obtaining the sanction of the Government to their scheme of drainage, or to the position of the outfalls, on the ground that as the metropolis paid for the works, they had a right to construct them in any way they thought fit. This doctrine was sound so far as the sewers within the metropolis are concerned, but it was most unsound, shortsighted, and unstatesmanlike in respect of the outfalls outside the metropolitan area, because upon the position of the outfalls depends the condition of the Lower Thames—that great navigable highway—in the length of which the metropolis occupies but a comparatively small portion. It is, however, clear, from the discussion which took place in Parliament, that it was intended that the sewage should be deodorised at the outfalls; and should not be turned into the river in a crude state.

This oversight of the interests which the public at large, independent of the metropolis, have in the Thames, was attempted to be remedied twelve years subsequently by the Thames Navigation Act of 1870, which provided that the Metropolitan Board of Works should, at their own expense, keep the Thames free from such banks or other obstructions to the navigation thereof as may have arisen or may arise from the flow of sewage at the outfalls, for the time being, into the river; but this Act makes no mention of the necessity of maintaining the purity of the Thames water, or of conditions which might affect health.

Upon the passing of the Act of 1858, the Metropolitan Board of Works proceeded to construct their sewerage system, which was estimated to cost somewhat under £3,000,000. The northern and southern outfalls were completed and in use in 1864, and the main drainage system was formally opened by H.R.H. the Prince of Wales, in 1865. The works are stated to have cost about £4,600,000, but no provision was made for deodorisation, the crude sewage being turned into the river at the outfalls.

It is also to be observed that the criticism of the referees upon the limited provision for carrying off the sewage made by the Metropolitan Board have been subsequently fully justified. In the report of the Metropolitan Board for 1881, occurs the following paragraph:—

"The floodings of heavy rains which have occurred on several occasions, in recent years, in some of the populous districts of London, principally those on a low level, made it necessary for the Board to determine upon the construction of some additional sewers to carry off the storm water. The cost of these additional works is mentioned at £1,000,000."

The report further says:—

"The Board have lately resolved to enlarge the reservoirs at Barking and Crossness outfalls to 50 per cent. beyond the present capacity, to admit of the largely increased quantity of sewage being stored until the ebb tide, instead of, as have been occasionally necessary, having to be discharged on the flood tide, and thus giving rise to complaints that the Thames water at Woolwich was impure."

And the Royal Commissioners on Metropolitan Sewage Discharge report that these extensions will bring the total expenditure to £6,250,000, without any works for deodorisation, as against the £5,438,000 stated by the referees to be necessary.

Whilst these large works were going on under the Metropolitan Board, it may be said that the whole system of minor sewerage and drainage in the metropolis was also undergoing revision, and considerable efforts have been made, by the use of catchpits and by regulation, to prevent road grit passing into the sewers. The subsidiary drains may be said generally to have been to a considerable extent changed from being sewers of deposit into self-cleansing sewers, although no doubt instances to the contrary may still exist.

In the central districts of the metropolis the extensive foreshores of the river, with their banks of mud, have been much diminished by the construction of the splendid embankments which extend on the north from Blackfriars to above Chelsea, and on the south from Westminster to Vauxhall. In other parts wharves have been raised to prevent the overflow of high tides. The general result of these works must be judged by the health of the population. If the death-rate be accepted as a test, it is noteworthy that the average death-rate of the decade 1841-50 was 24·8 per 1,000. If the conditions had remained *in statu quo*, except as to increase of population, the death-rate of 1871-80 ought to have been 26·2, according to Dr. Farr's tables for increase

due to density of population. In point of fact it was only 22·5. It may be contended that this is too high; but at any rate the diminution may fairly be put down to improved sanitary conditions, amongst which the drainage system stands prominently forward.

But in looking back at the history of the sewage question, it seems astonishing that good results could have emanated from the arrangement made in 1855. That arrangement abolished uniformity of control over the main roads of the metropolis; and whilst it gave the jurisdiction over main sewers to the Metropolitan Board of Works, it placed the district sewers under the control of separate Vestries; the control of the water supply remained in the hands of eight different companies. If there is one thing more certain than another, it is that a uniform control is especially necessary in the drainage and water supply of a district; the control over the sewerage especially should exist from the reception into a public sewer of the sewage from the house drain until it reaches the point of outfall. In the metropolis, Parliament has done its best to prevent uniformity, and to prevent the Metropolitan Board of Works from having a fair chance. If there had been such uniformity of control over the water supply and drainage, the quantity of water consumed, and consequently of sewage, might have been more effectually regulated: and if the details of the district drainage had been under one and the same authority as the main sewerage, it is quite possible that inasmuch as the conditions of the districts vary, so the sewerage might have been arranged in special cases on somewhat different lines. It is conceivable that in some parts, sparsely occupied, the separate system might have been to some extent introduced, although it was inadmissable in the more densely inhabited portions of the metropolis.

There have been now three public inquiries into the evils alleged to arise from the sewage discharge at the outfalls at Barking and in Erith Reach. The first was by Sir Robert Rawlinson in June, 1869, upon a complaint from the inhabitants of Barking that the river was silting up so as to affect the navigation, and that the pollution was dangerous to the health of the inhabitants of Barking. Sir Robert Rawlinson reported the allegation to be only partially proven, adding that the unsanitary condition of the town of Barking prevented the inhabitants from being in a position to establish deterioration of health from the London sewage, and that the main channel of the Thames had not been reduced; but that the Thames is polluted by the metropolitan sewage, and that deposits of mud had taken place on the shores of Barking Creek, but from what cause had not been proven.

The second inquiry was by means of an arbitration, under the Thames Navigation Act of 1870, between the Conservators of the Thames and the Metropolitan Board of Works. The Conservators of the Thames contended that certain mud banks had resulted from the discharge of sewage at the outfalls, and had injured the navigation. The arbitrators determined that the Barking and Halfway Reaches, in which the banks are situated, were better for navigation than when the outfalls were opened. That the banks had arisen from dredging operations carried on by the Conservators of the Thames, or sanctioned by them, such dredging having affected the direction of flow of the currents and altered the sectional area of the river.

The third inquiry was that recently held by the Royal Commission on Metropolitan Sewage Discharge, which was directed to ascertain whether any evil resulted from the discharge of sewage into the Thames by the Metropolitan Board of Works, and if so what measures could be applied for remedying or preventing the evil. The report shows generally that the pollution of the river arises from the large volume of the sewage thrown into it, in a locality where the area of the river is small in comparison to the volume of sewage discharged into it. The referees estimated that the total quantity of sewage from the metropolitan area discharged into the Thames in dry weather amounted, at the time of their inquiry, viz., in 1857, to 15,250,000 cubic feet per day. The population, which was then about 2,500,000, has now increased to something between 3,800,000 and 4,000,000, and in the report of the Royal Commission the volume of the dry weather sewage is now stated to amount to 23,000,000 cubic feet per day, which is an increase very nearly proportionate to the increase of population. The report of the Royal Commission states that the low water area of the river near the outfalls is about 30,000 square feet, and that this volume of sewage would fill a length of about 750 feet of the river at low water. At the present rate of increase of the metropolis, the population will amount to 6,000,000 in 1990, and at a proportionate rate of increase the

sewage will amount to nearly 35,000,000 cubic feet per day.

It must not, however, necessarily be assumed that the volume of sewage will continue to increase in the same proportion as hitherto, inasmuch as care in regulating the water supply would materially reduce the dry weather flow of sewage in London, as it has in Liverpool, Manchester, and other towns; but this seems to be one of those questions which must wait until the government of London has been consolidated under one jurisdiction.

The Royal Commission report that "we find it impossible not to be satisfied by the overwhelming amount of concurrent evidence as to the real existence, under certain conditions, of the nuisances complained of." The foreshores in the reaches near the outfalls are covered with black fetid mud in a highly putrescible condition, just as was the case with the foreshore in the heart of the metropolis before the construction of the intercepting sewers or of the embankments; they also report "that the fish have disappeared from this point of the river, and that their disappearance is due either directly or indirectly to the sewage discharge." They further report that the evils of the present system of discharging the metropolitan sewage are decidedly such as to require a remedy, and that the public interests require that such a remedy should be applied with the least possible delay.

Before proceeding further, it may be remarked that the report of the Royal Commission, just issued, is a model report; in so far that it is drawn up with great skill and care, and forms the most valuable survey of the state of the question on water-carried sewage disposal which has ever yet been issued.

In order to appreciate the effect of turning in the large mass of sewage into the river in a concentrated form, it is necessary to note the influences exercised by the sewage upon the river. The report of the Royal Commission shows that although the outfalls are at Barking and Crossness, and the sewage may be assumed to be turned into the river only on the ebb tide, yet the float experiments showed that at whatever time of the tide the sewage is discharged, some of it may, under certain conditions, be carried up by the tidal oscillation alone into the heart of the metropolis, and even further. The report states that, in fact, the chemical analyses show that there is a progressive increasing impurity of the river from Teddington downwards to the outfalls, and then a decreasing impurity to Gravesend, beyond which place the sewage is not perceptible. As regards the impurity in the metropolis above the outfalls, it must, however, be recollected that on most rainy days sewage is allowed to flow through the storm overflows into the river in the metropolis; and, moreover, sewage also passes into the Thames in the tidal estuary above the metropolitan area. The oxygen dissolved in the water exhibits a corresponding decrease as the sewage increases, and *vice versa*; which shows that the oxygen does active work in oxidising, and thus purifying the river from sewage impurity; in addition to the effect of oxygen, purification is assisted by animal and vegetable life. Thus the sequence may be summed up as, first, pollution by sewage; second, oxidation of the sewage; third, consumption of the sewage by minute animals, by the re-oxygenation of the river by means of animal and vegetable life, and by renewed absorption of oxygen from the air, which is favoured by the movement of the water by tide and wind.

The larger the volume of tidal water, in proportion to the sewage, the more rapid is the effect of these processes. An interesting series of experiments which Dr. Tidy made in 1878 and 1879 corroborates this view. They are recorded in a paper read before the Chemical Society in May, 1880. He mentioned one case where a liquid, containing one part of sewage to twelve of water, flowed a distance of one mile in nine hours; the oxygen required to oxidise the organic matter was ·538 grains before the experiment, as compared with ·187 grains after the experiment, showing as the result of one mile flow a diminution of ·351 grains of the oxygen required. The organic carbon, organic nitrogen, and chlorine were also materially diminished. Dr. Tidy recently remarked upon these experiments, "I am certain that given a dilution of one-seventh sewage and six-sevenths fresh water (fully aërated, *i.e.*, containing two cubic inches of oxygen per gallon), with a flow of two miles per hour, not a trace of noxious matter would be found at a distance of five miles." It is worthy of remark that, at the places suggested by the referees for the discharge of the sewage, viz., opposite Mucking Lighthouse, the low water area of the river is 191,000 square feet, and the high water area 304,000 square feet; moreover, the sewage, as proposed to be diluted by the referees, would, after its course of twenty miles along the outfall channels at a rate of nearly two miles per hour,

have reached the river in a condition much more favourable for dispersion than is the crude sewage turned in at Barking and Erith. And there can be no doubt but that if the suggestion of the referees had been adopted, the question of the pollution of the Thames by the metropolitan sewage discharge would not have arisen in the present generation.

In proposing a remedy, the Royal Commission accept the general principles which have guided the design of the metropolitan sewage system. They recognise the difficulties which have been felt of separating the rainfall from the sewage in the metropolis, difficulties which have been equally felt by all the various authorities who have hitherto been consulted on the subject. They state that it is neither necessary nor justifiable to discharge the sewage in a crude state into any part of the Thames. In considering how it should be dealt with, the Commissioners received a large amount of evidence on the different methods of sewage purification, as, for instance, treatment with lime, with perchloride of iron, by means of the A B C process, the filtration through limited areas of land, broad irrigation, &c. Colonel Jones suggested that the sewage should be conveyed to Canvey Island, and then allowed to deposit in shallow cuts without the use of chemicals, the liquid, when clear, being run into the river.

There are two points connected with the London sewage which do not seem to have been sufficiently taken into account in many of these proposals. The first, is that the time which necessarily elapses before the sewage reaches the outfall, precludes it from being in so favourable a condition for treatment or utilisation as fresh sewage would be. The second, that the degree of purity which should be required in an effluent depends on the degree of purity of the water into which it flows. The first of these, viz., the condition of the sewage when it reaches the outfall, has an important bearing upon the extent to which treatment with lime will prove advantageous, for in proportion to the freshness of the sewage is the efficiency of the lime process. The degree of freshness of character of the sewage has also an important bearing upon the utilisation of the sewage on land, and the prospect of deriving profit from the constituents. This part of the question has not, indeed, advanced much during the last twenty-five years; the remarks of Messrs. Hofmann and Witt, in their report to the referees, are nearly as applicable to-day as they were in 1857, viz., "notwithstanding the variety of patents which have been taken out, the problem of recovering profitably the valuable constituents of sewage remains unsolved. The valuable constituents of sewage are like the gold in the sands of the Rhine, its aggregate value must be immense, but no one has succeeded in raising the treasure."

After weighing very carefully the evidence which they received on this part of the question, the conclusion at which the Commission arrive is practically the same that has been arrived at in previous inquiries, viz., that the metropolitan sewage had best be got rid of at the smallest cost compatible with efficiency. The Commission state that the suspended solid matters in the sewage are the chief causes of nuisance, and that by precipitation the suspended matter may be almost entirely removed, and the tendency to deposit largely lessened; but that the result of discharging an effluent alkalised by lime into the river at the present outfalls is problematical; they think, however, that lime would probably be as good as any other chemical for purposes of precipitation. The Commission add—

1. That a process of precipitation would effect an improvement on the present state of things. It would lessen the tendency to deposit foul banks and shoals.

2. That precipitation alone would not finally purify the river; nuisance would still occur in dry weather. That the injury to fish and danger to wells would still remain.

3. That the precipitation works themselves might be carried on without sensible nuisance.

4. That the cost of the precipitation would be at least £200,000 a year, or 1s. per head of the population.

5. That it would result practically in the loss of a large part of the manurial value of the sewage, offering no prospect of future realisation, except by applying the clarified liquid to land.

For these reasons, and apparently also because a precipitation process could be brought into use more quickly than any other remedy, and if disused would entail a comparatively small loss of capital, they conclude that some process of deposition or precipitation should be applied to the London sewage at the present outfalls. The sludge would be either applied to the raising of low lying land (it is to be hoped not to serve for the foundations of future dwellings); or burnt, or dug into land, or carried away to sea. The liquid portion would be, as a temporary measure,

allowed to escape into the river. The report goes on to say that, as a permanent measure this liquid must be further purified, by being passed through land, or else must be carried down to Hole Haven.

According to the experience of Birmingham, which is not a water-closeted town (that is to say, only one-eighth of the houses have water-closets), the amount of land necessary for the metropolitan sewage, after treatment with lime, would be 6,000 acres, and the cost of the capital outlay for land and necessary works for the metropolis, upon the basis of the Birmingham expenditure, would apparently be fully £1,500,000. Mr. Bailey Denton states, however, in his most recent publication, that one acre of suitable land properly prepared would purify the clarified sewage of 2,000 persons; upon that basis at the present time the clarified sewage of the metropolis would require about 2,000 acres of land. The preparation of the land varies in cost, according to Mr. Bailey Denton, from £30 to £150 an acre. The Commission estimate the annual expenditure for precipitation by lime alone, on the present population, at £200,000 a year, which represents a capital sum of about £6,000,000, at 3¼ per cent.; or assuming that a rental could be got for the land of from £6 to £8 per acre per annum, it would still stand against the metropolitan ratepayers at £4,500,000. This estimate, however, appears to be based only upon the present dry weather flow of about 23,000,000 cubic feet of sewage for twenty-four hours. But in times of rain the sewers are capable of bringing down more than three times that quantity to the reservoirs, the excess would apparently flow direct into the river, and this probably on about one day in three. It may be observed, in passing, that whilst the dry weather sewage contains on an average 23·36 grains of solid matter per gallon, of which 9·44 is mineral, and 13·92 is organic matter; in wet weather, when rain is intermittent, the sewage may contain from twice to five times this quantity of solid matter, of which no doubt the larger part is mineral, but the organic matter is also very largely increased. In continuous wet weather, on the other hand, the sewage may become abnormally weak. The recommendations of the Royal Commission will not, therefore, deal thoroughly with the question, as in wet weather a large quantity of sewage will still pass in a crude form into the river. Moreover, according to the rate of increase of the metropolis, the sewage will amount to 35,000,000 cubic feet in little over twenty years. The cost of settling beds and land for purification, as well as the annual cost of the purification, will have to be increased in proportion, and, therefore, the question may be fairly raised whether it will not be a serious waste of money to adopt so expensive a palliative. And if the final result of the deodorisation and filtration through land is to return a portion only of the effluent purified to the river, at a cost equivalent at the present time to a capital outlay of £4,500,000, which will mount up at no distant date, with the increase of population and consequent sewage, to £6,000,000, in addition to the immediate expenditure of probably £1,500,000 for land and works, might it not be simpler and cheaper even now, to adopt the plan of modified deodorisation suggested by the referees, viz., dilution of the sewage, combined with its flow through many miles of long tidal channels, at a cost of two and a-quarter millions or less.

It will be apparent that one of the principal difficulties of the sewage question in the metropolis arises from the concentration of so vast a quantity of sewage, which is carried down to the outfalls and turned into the river at two points near each other. Sir Joseph Bazalgette, in his evidence before the Royal Commission, contemplates an extension of this amount of sewage, by bringing into one scheme the sewage from the valley of the Lea up to Hertford, and the Thames valley sewage, with its tributaries, from Leatherhead, Epsom, Ewell, Cheam, and Sutton.

There is no doubt that the question of the disposal of the sewage of the metropolitan area is only one part of the subject, and that the whole question of the disposal of the sewage of the valleys of the rivers Thames and Lea requires to be taken into account and dealt with in a comprehensive manner. And this subject must daily increase in importance as inducements are held out to the working population of London to reside in more airy localities outside London, and to come up daily to their work; for it is certain that, unless this question of the disposal of the refuse water of these outlying districts is taken in hand earnestly and zealously, the community will in a few years find itself in a much more difficult position than it is now placed in by the question of the metropolitan sewage alone.

It is clearly not advisable to allow the sewage from outlying districts to flow through the heart of the population of London. The

referees, in their report, especially alluded to this point. They said:—"It is desirable, as far as possible, to prevent the sewage from flowing through the thickly inhabited districts of the town;" and so strongly were they impressed with this view that they recommended "that the low-level sewage west of Somerset House should be carried back to opposite Battersea, and then across the river, to be there raised into a southern high-level sewer," passing through a comparatively sparsely inhabited district, instead of passing, as it now does, through the most densely populated part of London.

This brings us to the question as to whether the limits of concentration have not been fully reached, so far as the metropolis and its subsidiary districts are concerned. Indeed, it could be argued, with some show of reason, that it might have been advisable to have adopted, in some parts of the sparsely inhabited western districts of the metropolis, in a modified form, the separation of sewage and rainfall, and possibly to have refrained from pumping twice over the sewage of the districts of the western portion of the metropolitan area, in order to convey it through the heart of the more populous parts of London to Barking or Crossness; and instead of this to have resorted to some form of purification. In the present state of the question, this is only a reflection which occurs as to what might have been best with our present experience if the field were clear.

But with respect to the sewage of districts outside the metropolis, the subject is largely one where future action is less fettered by former proceedings. No doubt, even if it were admitted as an axiom that sewage of outlying populations should not be allowed to flow through densely inhabited districts, yet it is possible that sewers might be arranged to carry the sewage from the places in question to the sea. But is this necessary, or is it desirable? If sewage from places in the Thames Valley above the metropolis, or from the valley of the Lea, is required to be taken to the sea, where are we to stop? The difficulties of the sewage question arise from concentration, and it is therefore a much more rational solution to give up the idea of concentration, and to require each district to make arrangements for the disposal of its own sewage.

If a population concentrates itself on a limited area, it must make arrangements for the wants entailed upon it by that concentration. For instance, it must provide streets to give access to the houses; it must provide open spaces in which to marshal the railway trains which bring in the food or other articles which minister to the daily wants of the population. It must provide gathering grounds for its water supply, parks for recreation, and open spaces in which to bury its dead. Similarly it is equally necessary that every nucleus of population should provide open spaces on which to purify its sewage without being offensive to neighbouring houses.

The report of the Royal Commission makes it abundantly clear that whilst profit must not be expected from sewage utilisation, yet that precipitation and utilisation are eminently fitted, when properly applied, to produce a purified effluent; and, therefore, that were certain conditions of population and of sewage always observed, each district could be made self-contained in respect of its sewage just as it can be in respect of its cemetery.

1. The conditions of population is that the district should be limited in numbers and in the area occupied.

2. The conditions of the sewage are—(*a*) the extent to which the sewage can be separated from the rainfall; (*b*) the degree of freshness of the sewage, as received at the place where it is treated.

In the case of the metropolis it may be accepted that the removal of sewage and rainfall was a necessity, and in this view all the practical authorities who have considered the subject appear to concur. The reasons for combining sewage and rainfall are not always equally strong, and in many cases the strength of the argument is against combination. But no absolute general law can be laid down that sewage should invariably be separated from rainfall. On this question each locality must be governed by the circumstances of the case; but there can be no question that the problem of sewage disposal would be simplified almost in direct proportion to the extent to which the separation of sewage from rainfall can be carried with prudence. The difficulties of separation lie in the numerous foul surfaces which prevail in towns, and especially in streets of large traffic, in which, in proportion as the road surfaces are rendered smooth and impervious, so does the mud and the dust appear to consist chiefly of horse manure, and this could only be prevented by the adoption of a much more perfect system of street cleansing than prevails at present.

The importance of the report of the Royal Commission lies not so much in what it recommends for the metropolis, as in the valuable information which it has collected on the present state of the general question of sewage disposal—information which is applicable to the wants of the whole country. The comprehensive manner in which the subject has been treated is of especial value at the present time, because the country is becoming too closely built over for this question to be allowed to remain any longer in the *laissez faire* condition which it has hitherto occupied, if regard is to be had to the purity of the air, the purity of the soil, or the purity of the rivers and water-courses.

DISCUSSION.

The CHAIRMAN said he should not occupy time by discussing this question himself, but having had a great deal to do with it in various aspects, he must just say how entirely he agreed with Captain Galton as to the value of the report of the Royal Commission.

Col. EWART, C.B., said there was not much to add to the report of the Royal Commission, and he did not know that it would be becoming in him, as one of the Commissioners, to enter into an elaborate discussion of the subject; he only hoped the report would be as useful to the profession and the public as Captain Galton seemed to anticipate. It would, perhaps, have been an advantage if the latter part of the evidence had been in Captain Galton's hands, as it was very interesting and important, but it had not yet been made public. One leading point in which the Royal Commission differed from the referees was, that the sewage instead of being taken down on both sides of the river, should be conveyed across in a tunnel, and carried down on one side only, the evidence being very strong that that course would have advantages outweighing the cost of the tunnel. With regard to the question where the sewage should be taken to, in the event of the alternate scheme being adopted, the report used the word "about," no definite spot being laid down, much further inquiry into matters of detail being necessary before such a point could be settled, and the Commission had rather endeavoured to deal with matters of principle.

Admiral Sir FREDERICK NICOLSON, Bart., C.B., wished to say, on behalf of the Conservators of the Thames, that they fully appreciated the value of the report now under consideration, and hoped the result would be, without any very great delay to prevent what was undoubtedly going on, though being gradual, it was not observed by every one—the interference with the navigation by so much semi-solid sewage being poured into the river. On a remarkable day last summer he accompanied the Royal Commissioners down the river, and certainly, if they required any evidence to convince them that something should be done, it must have been afforded then, for the river opposite Woolwich Dockyard was nothing but one black stream of sewage.

Mr. J. SUTTON thought too much stress had been laid on the value of sewage as a manure. He had been connected with some experiments at Barking, in which some tons were dried at a low temperature, but on being submitted to the late Dr. Voelcker for analysis, he put the value at only 10s. to 12s. a ton, which would not exceed the cost of carriage. In other towns, where the sewage had not such a distance to travel, it might perhaps be more valuable.

Mr. D. KER described a plan which he had devised for rendering the sludge more valuable, by mixing it with specially prepared Irish peat. In drying it, as described by the last speaker, the greater part of the ammonia, which was the most valuable constituent, was driven off, and the same thing occurred by the use of lime, but his method retained the ammonia and alkalies.

Dr. DRYSDALE said they were now asked to sanction a plan by which the whole of the London sewage should be taken down somewhere near Gravesend, or perhaps further, and thrown into the sea; but, as pointed out by Liebig many years ago, this was a most reckless waste of valuable material. In 1878, when this subject was examined in Paris, it was found that the river, which had before been as much polluted as the Thames, had been entirely purified by the passage of the sewage through agricultural land. If the same plan were universally adopted, every country in the world would become sterilised. In China, the sewage could not be thrown into the seas, and consequently every atom was made use of. China had existed for ten or twelve thousand years, but if England went on throwing away all her nitrogen and ammonia in the way proposed, she would certainly not last so long. He did not propose merely to purify the sewage, but to utilise it. At Gennevilliers, near Paris, the proprietors at first would not use the sewage, but they soon found the advantage, as they were able to grow three or four times as much produce as they did before; and the effluent which passed into the Seine was quite fit to drink.

Mr. E. BAILEY DENTON, said that, after listening to the paper, the impression left upon his mind was not of a very tangible character. It in no way gave

a solution of the difficulties so exhaustively presented by the Royal Commission. The author's advice was to revert, as a means of ridding the river of the nuisance so conclusively condemned by the Commission, to the open tidal channels which were recommended by the referees in 1855, and which were to run parallel to the river for twenty-four miles. If this idea were not entertained at the time of its proposal, it must be assumed that it was rejected for very good reasons, and we ought now to bring to bear upon the subject the experience subsequently gained. There can be no doubt that the recommendations of the Royal Commissioners presented the best solution of the difficulties they had proved to exist, and that precipitation at or near the present outfalls must precede any subsequent treatment. There then remained two proposals to be dealt with—firstly, discharging the clarified affluent without further treatment into the river at Hole Haven or elsewhere, where it might cause a nuisance; and, secondly, applying the effluent, after precipitation, to sand, so as to ensure its complete purification before its being turned into the river. He supported this latter proposition with special reference to intermittent filtration through natural soil, and the discharge of the purified effluent into the river at the nearest available point. The first proposition was needlessly wasteful, being more costly in primary outlay without any manurial return, and, in the end, it would probably prove unsatisfactory; whilst the combined treatment of precipitation and intermittent filtration might be performed not only with certainty of success but with comparative economy. This conclusion he arrived at after considerable experience in connection with his father (Mr. Bailey-Denton), who had closely investigated the question, especially in connection with the metropolis. That experience led to the belief that 3,750 acres would do the work well, since one acre of suitable land, properly prepared, ensured the purification in perpetuity of the sewage of two thousand persons after clarification. After local examination. it was found that there was an ample quantity of land above the river marshes, between Barking and Tilbury, thoroughly suitable in quality and configuration, and that no real nuisance and consequent depreciation of property could result from its utilisation, particularly if, as had been suggested by Mr. Bailey-Denton, a marginal breadth of land, outside the irrigated land, were purchased, which would be treated as "clearance land" to which no sewage would be applied, and beyond which no smell could be traced. Four thousand acres of such land could be bought and laid out for the reception of sewage for a million sterling, exclusive of pumping, and being free from the objections attending the presence of sludge, would yield a rental of from £5 to £6 per acre. Captain Galton said that on one day in every three, when the sewage was swollen by rainfall, it would have to be turned into the river in its crude state, and, therefore, the area of land would have to be increased, as well as the tanks and expenses of purification. But this would not be the case, for on the assumption that under any circumstances precipitation at the outfalls would precede application to sand, the sludge would thereby be removed, and the increased quantity of clarified liquid due to rain would not have any impeding effect. In conclusion, he hoped every one agreed with Captain Galton when he expressed his hope that the suburbs of London would not be allowed to join their sewage with the metropolitan sewage pure and simple.

Mr. BALDWIN LATHAM said there were three gentlemen intimately connected with the early history of the sewage of the metropolis who were not mentioned in the paper. The first scheme for the interception of the sewage of the higher levels was proposed by Mr. Martin, the well-known artist, who proposed to make intercepting sewers on each side of the river, and to take the sewage below London. The next scheme was that of Mr. Phillips, to make one great sewer for dealing with the sewage of London and the districts outside. Then the old Commissioners of Sewers invited competitive plans, one being very similar to that which had since been carried out. That was the one sent in by Messrs. Maclean and Stileman, and one feature of it was the extension of the outfall to the sea, and the reclamation of lands on the shore of the German Ocean. The referees' scheme embraced one important principle, which had since been lost sight of, viz., it dealt with a natural drainage district, not with a limited area like that of the Metropolitan Board. The consequence was that the districts on the borders of the metropolis were in great difficulties to know what to do with their sewage. In his judgment, whatever was done in future for the metropolis, the whole of what was termed greater London should be included in one great scheme. The mode of dealing with the sewage was a matter of detail, and he was of opinion that the best and cheapest way would be to make a high level sewer on the northern bank, and take the sewage right away to the deep water of the sea. There were great difficulties in taking it anywhere into the river itself, for if it were turned in near the mouth, it would prevent any fish from entering it. At the point where it was proposed to pour it in, the outward movement was the slowest, and it would take several days to travel a mile; so that you might get the accumulation of twenty days or more at the bottom part of the river, where it would be very deleterious mixed with sea water. Unless the water had a considerable degree of purity there, it would be utter ruin to Southend. He quite agreed with the views of the Commissioners as to the number of people per acre on the intermittent filtration system. It had been shown, as Dr. Drysdale had stated, that the purification of sewage was really due to the microbes in the soil, and the investigations of Mr. Warrington showed that no

nitrification took place below eighteen inches from the surface. The depth of the filter bed, therefore, was of little importance. The mode of precipitation must also be considered, for, as Mr. Warington had shown, lime absolutely destroyed those minute organisms on which the success of filtration depended. There were several methods by which sewage could be utilised, especially in small districts, but he feared the day was not likely to come when every town could get sufficient land to utilise its own sewage in its own neighbourhood. Where was the land to be obtained in the neighbourhood of the metropolis? If districts were to be restricted in the number of their inhabitants, it would be very difficult to decide whose land should be used for building operations, and whose should be devoted to other purposes. If such a scheme as he suggested be adopted, it would enable many of those plans which had been proposed for the reclamation of waste land to be carried out with advantage.

Prof. De Chaumont, F.R.S., feared there might have been a false impression produced as to the action of the Royal Commission, especially with regard to the alternative proposal to put the effluent after precipitation into the Thames, without further treatment, at Hole Haven. That was only put forward as an alternative supposing it were found impracticable to purify the effluent by any means, such as filtration through land. The Commission had some difficulty in coming to a conclusion on this point, on account of the deficiency of information with regard to available land sufficiently near the outfall; and they were still further puzzled by the great imperfection of the published maps of the Geological Survey, which gave only the subsoil strata, and contained no information as to the surface, which was really the important parts. It was not until they had the evidence of Mr. Whitaker, which would be published in the concluding volume, that they discovered that there really was sufficient land in the neighbourhood of Barking for the purpose of purifying the effluent. Then the Commission had no hesitation in coming to the conclusion that that was the process to be recommended. The Commissioners had a twofold object, one to find a good and reasonably permanent method of dealing with the metropolitan sewage, and the other to put before the Metropolitan Board and the public some means of dealing with the existing evil in a rapid and easy way; and it seemed to them that it was perfectly practicable without any great extension of works or loss of time, to put in practice a system of precipitation, and that if that were done, and the solids removed, the effluent might, at any rate for the present, go into the Thames. This, however, was not put forward as a perfect method, but simply as a relief to the abominable state of things now existing. Dr. Drysdale had referred to the value of the material proposed to be thrown into the sea, and they knew perfectly well there was a deal of valuable matter in sewage; but he believed its comparison to the gold in the sands of the Rhine was perfectly just. The value of the ammonia in London sewage, at the present price, might be taken at about a million and a quarter sterling, and that seemed an enormous sum, but if you had to spend £2 in getting every £1 worth of it, there was not much advantage in the process. Until they able to find an economical method of applying sewage to land, it was much better to throw it away as a nuisance. Evidence had been given again by men of the greatest experience, both chemists and engineers, that the cheapest and best way of dealing with it was to throw it away, for there was not the least chance in the present state of knowledge of applying the sewage of London to any really profitable purpose. You might apply it and get the crops, but there would be no profit. On this point, however, there was some difference of opinion. Colonel Hope argued that sewage might be a source of enormous profit, but his view was that the cost of taking it into the land must not be considered. The day might come when it would be profitable to apply sewage to land, but it had not come yet. There were two typical cases usually cited, the Craigentinny meadows near Edinburgh, and Gennevilliers, near Paris. No one, he presumed, would advocate the creation of such a nuisance as existed in the former case, and the latter was quite exceptional, being the case of an island of waste land especially suited to the purpose.

Mr. De Rance, as an officer of the Geological Survey, wished to state that two editions of the geological maps were published; one showing only the solid rocks, as had been stated, and the other showing the surface; and the very reason which induced the late Sir Roderick Murchison to have these maps prepared, was the important bearing the surface of the soil had on sanitary matters. The officials of the Local Government Board had constant recourse to them, he understood; a large portion of the valley of the Thames, the whole of Lancashire, and a great part of Yorkshire, were already published, and a part of the staff were now in Scotland, preparing the superficial survey of that country.

Dr. W. Pole, F.R.S., said what the last speaker said was perfectly true, but there did not appear to be any means taken to let the public know of the existence of these maps, and it was not until Mr. Whitaker had given his evidence that the Royal Commission were aware of them.

Mr. W. C. Sillar wished to correct a misapprehension which might be created by Mr. Latham's remark, that the turning of effluent water from a precipitation process into the river would prevent any fish coming up. He need only mention the fact that a gold medal was presented at the Fisheries Exhibition for a process under which sewage was so purified that fish lived in it the whole time of the Exhibition. He would also mention that mere precipitation would

still leave the sludge at the bottom, and although the nuisance would be removed from the river, unless it were deodorised, there would be just as much difficulty in dealing with it on shore. At Aylesbury, where a precipitation process had been in operation for some years, although land was purchased for the purpose of filtration if it were found needful, it had never been used; and yet the late Dr. Angus Smith certified that the effluent was perfectly satisfactory.

Mr. T. W. B. MUMFORD said he believed most Local Boards who had tried to grapple with this question put an undue value on the sewage sludge, but on the other hand, it might be undervalued also. Some short time since he had a sample sent him (being engaged in manufacturing fertilisers on the Thames, and, therefore, being interested in the question on every ground) of compressed sludge from Leyton, which he found contained 1·28 per cent. of ammonia, the organic matter and water being nearly 52 per cent.; the moisture being 31 per cent. It was perfectly inodorous and ground up very well, and also contained potash and soda in small quantity, and 5·39 per cent. of phosphate of lime. If the authorities could obtain a pure effluent and get back even 25 per cent. of their outlay from a bye-product of this class, it was worth considering.

The CHAIRMAN said he believed the process referred to was worked at Coventry for some years by a company, who received £2,200 per annum, and whatever they could make by the product, but, nevertheless, it had failed.

Mr. MUMFORD said the Leyton Local Board were still carrying on the process, and the sample submitted to him was prepared by the Board, not by the company.

The CHAIRMAN said he understood it cost about 3s. 6d. per ton to solidify the sludge, and it fetched about 1s.

Mr. MUMFORD said he had purchased about fifty tons of it at 10s. per ton.

Lieut.-Col. JONES, V.C., thought if any profit were to be made out of sludge, he should have found it out; but he was quite satisfied that in a case like that of London, where the quantity to be dealt with was so enormous, the best thing was to bury it out of sight as soon as possible. At the same time he would not undervalue sewage sludge, for he had found the benefit of it on his farm, which he had made to pay in seasons when those around him had been losing money, though paying only one-third the rent. But the profit, whatever it was, should go to the farmer, not to the ratepayer; the local authorities ought to be satisfied to get rid of a nuisance at the smallest possible expense. In a case like London, the great thing was to take out the solid matter; if you could get people to utilise it, so much the better; if not, throw it into the sea reach.

The CHAIRMAN said he was sure the gentleman who referred to China knew nothing of the Chinese process of dealing with human excreta, or he would not advocate its adoption. We had examples of it in the so-called tub process and the portable pail process, which were two abominations, but they were purity itself compared with the Chinese method. As Sir Rutherford Alcock said, you could not ride a mile out of any city in China without being overwhelmed with an intolerable stench, and he did not think you could find an atmosphere sufficiently pure to enjoy life in, unless you climbed to the crater of a volcano.

Captain DOUGLAS GALTON, in reply, said Colonel Ewart had remarked that the Commission had not gone into details; but the whole question was absolutely one of details. It was very easy to theorise on the question of London sewage, but the whole practicability of any scheme depended entirely on the details. With reference to the question of deodorisation by lime, and the sludge, the sludge was the real difficulty. It might have a certain value when it could be disposed of within a limited area, but when you were producing nearly 500 tons a day, or close upon 200,000 tons a year, it became an enormous difficulty to dispose of it in any way at all. It represented a mass of material a mile long, 60 feet broad, and 15 feet deep. He agreed with Mr. Baldwin Latham that it would be much wiser to throw the whole mass into the sea, and it would be probably cheaper in the end to make a channel and carry it straight out into deep water than to adopt the plan now proposed.

The CHAIRMAN then proposed a vote of thanks to Captain Douglas Galton, which was carried unanimously, and the meeting adjourned.

Mr. EDWIN CHADWICK, C.B., writes:—I regret that I do not feel myself up to attending and taking part in the discussion to-night, for I feel myself particularly depressed by the calamity that has befallen us by the death of General Gordon; and I would mention, as illustrative of his deep, kindly, and many-sided nature, that in him we have lost a genial ally in our work for the mixed mental and physical training of the most depressed classes of children. I had the honour of a visit from him on the subject, and communicated with him upon it, and visited him whilst he was stationed at Gravesend, whence he took me over to Grays to witness the exercises of the boys of the *Goliath*, the training ship under Captain Bourchier. The people of Gravesend will be aware of the active interest which Gordon took when there in the better training of the gutter children. It was a dream of mine that, had he been spared and

returned, we might have got him to preside over another exhibition of the physical training of the district half-time schools, such as we had in Hyde-park, in which he would undoubtedly have had the greatest sympathy. Let me observe, in respect to the subject-matter of the discussion to-night, that I consider that Captain Galton is well justified in bringing forward the project of his fellow referees, and of himself, averring that if it had been adopted, the question of the pollution of the Thames by the metropolitan sewage discharge would not have arisen in the present generation; that is to say, that they would have accomplished at an expenditure of five millions and a-half what has cost more than six millions, and has, up to this time, resulted in a condition of the river which Lord Bramwell and his colleagues have pronounced to be "a disgrace to the metropolis and to civilisation." I have elsewhere written at great length on the subject of the report—in a paper—in which those who are at the pains to investigate the subject will find the following conclusions substantiated:—That the condition of the River Thames is due to the system of carrying off rain and storm water in the same channels as the sewage proper, whereas the cost of this, viz., upwards of six millions of money, would, on the separate system, have sufficed for the purification of the houses and the streets of the greater part of the metropolis from the products of stagnant decomposition, and would have largely reduced the enormous expenses of excessive sickness, loss of work, and premature mortality. That further proceeding with the combined system is to continue injurious waste, and to impose aggravated money burthens on the population threefold greater than the burthen of the poor rates. That the separate system has been carried out in a number of towns, with variations in the executive details, and that it would be of advantage if these variations were closely examined, with a view to the application of the experience of the best results to the relief of the metropolis. That whether the sewage be destined to feed vegetation or to feed fish it must be delivered not in a condition of putridity, but fresh; that it must be delivered fresh on the land to augment its power of agricultural production, and also to avoid the necessity of carrying it to excessive distances. That chemical disinfectants, deodorisers, or intermittent filtrations, are not needed when sewage is discharged fresh, or before the commencement of putrefactive decomposition. That the sewage can only be obtained fresh by the separate system. That the water pumped into the metropolis by the trading companies is greatly in excess of the actual domestic consumption. That the effect of this waste of water is to reduce proportionately the value of the sewage as manure, to increase the cost of its distribution, and to reduce the possible returns from sewage farming. That the effective reduction of this waste of water would largely reduce the supplies from sewage tainted river sources. But that the London trading water companies have failed to reduce this waste, and that i can only be effectually reduced, as at Manchester and at Liverpool, when the supplies for the metropolis are put, as there, under unity of management on a public footing, as recommended by preceding Royal Commissions and Select Committees of Parliament. That to arrest the continued expense and waste, and to promote efficient means of the improvement of the condition of the population, the local administration of the metropolis should be placed with the least delay under complete municipal unity, with securities for the application of special science for good government and supervision.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

Choral Competitions.

The following general regulations have been adopted by the Executive Council of the Exhibition:—

1. All applications for admission to the competitions must be made to the Secretary (on printed forms provided for the purpose by him) not later than 1st April, 1885.

2. A certificate will be required under the signature of the conductor and secretary of each choir entering for competition, declaring that the choir has been actually constituted for not less than six months prior to the date of application.

3. Choirs must enter (1) as consisting entirely of amateurs, or (2) as consisting of amateurs assisted by professionals; but under the latter head no choir will be eligible to compete which has a larger proportion of professionals than one professional member to every fifteen amateurs; and the names and addresses of all professional members must accompany the application. No professional will be allowed to take part in any competition who has not been a member of a choir to which he belongs for at least six months prior to the date of filing applications (April 1st, 1885). [By a "professional" is meant any person who is receiving, or has received, pay for musical services rendered, either to the particular choir or to any other persons or body.]

4. Each choir will be required to sing two unaccompanied pieces selected by the Council, the names of which will be given on entering the choir for competition, and also one unaccompanied piece of its own selection. The choirs of female voices will, however, be allowed a pianoforte accompaniment to two of the three pieces selected.

5. By "member of a choir" is meant a performing member.

6. If only a portion of a choir, or a selection of members, enters for competition, this must be stated, and full particulars given as to the number of non-competing members, and why they are absent.

7. No competition will take place in Classes I. or II. unless three choirs at least enter in either class; and no competition will take place in Classes III. and IV. unless two choirs at least enter under either class; and no competition in Class V. or VI. unless two choirs shall enter under either class; but it shall be in the power of the musical umpires to recommend a gift of money to any deserving choir excluded from competition from this cause only.

8. Secretaries of choirs are required to communicate with the Official Agent of the Exhibition, 96, London-wall, E.C., relative to the arrangements which the Executive Council have made with the railway companies, whereby special facilities may be secured by the choirs for travelling on favourable terms. Actual competitors will receive free admission to the Exhibition.

In addition to such sums as may be given from local sources, the Executive Council have determined to award the following prizes:—

PRIZES.

Class I.—Choirs of mixed voices (trebles, altos, tenors, basses), numbering not less than 100 members—first prize, £100; second prize, £60; third prize, £30.

Class II.—Choirs of mixed voices (trebles, altos, tenors, basses, numbering not less 50 or more than 100 members—first prize, £60; second prize, £35; third prize, £15.

Class III.—Choirs of female voices only, numbering not less than 50 or more than 100 members—first prize, £60; second prize, £40.

Class IV.—Choirs of female voices only, numbering not less than 30 or more than 50 members—first prize, £30; second prize, £20.

Class V.—Choir of men's voices, numbering not less than 60—first prize, £60; second prize, £40.

Class VI.—Choir of men's voices, numbering not less than 30 or more than 100 members—first prize, £30; second prize, £20.

The total amount of the prizes is £600.

ANTWERP INTERNATIONAL EXHIBITION, 1885.

The maritime section of this Exhibition, on the river and in the docks, will be a novel attraction. France will supply steam-launches, and various other descriptions of boats and life-saving apparatus, which will be floated in the dock set apart for this exhibition. The large building establishment, the Vulcan of Stettin, is charged with making a collective exhibition of the steamboat builders of Germany. It is hoped that England will also participate largely. Already, the P. and O. Company; Laird Bros., Birkenhead; Swan and Hunter, Wallsend; and others, exhibit models. Trials, for the purpose of testing speed, stability, &c., will take place in the Scheldt. Belgium will exhibit a despatch-boat, constructed for the Government. Tunis intends to exhibit, and will occupy a space of about 500 square metres, next to the French compartment.

The international gallery of machinery in motion has had to be enlarged, and promises to be remarkably interesting, the principal object being to bring into prominence the advantages derived from the application of steam-apparatus set in motion, either by water, gas, or elecricity, for use on small premises. All objects manufactured within the building will be for sale.

The applications for space in the machinery department continue to be so numerous, that the committee have decided to increase the space originally set aside for this section. Large manufacturers, such as the firm of Heilmann Duirmann, of Mulhouse, have received from 400 to 500 square metres of space. The exhibitors from Germany number over 900.

Messrs. Siemens and Halske, of Berlin, have offered to illuminate the German Section gratuitously by the electric light; and others will light the machine gallery, the central gallery, and the gardens.

The Belgian Chambers have voted a subsidy of £20,000 towards the expenses of the Exhibition. A portion of this sum will, it is said, be applied to the organisation of an agricultural show at Antwerp. In the grounds there will be many attractions—as a captive balloon, a Canadian farm, an orchestra, and many handsome kiosks and restaurants. The French Colonial Section will be extensive, and near it will be those of the colonies of Portugal, Dutch Indies, and several American colonies, especially Canada, which has secured a large space. It is also stated that the Minister of Public Works intends establishing trains, supplied with restaurants, to run between Brussels and Antwerp during the Exhibition.

NOTES ON SILK-PRODUCING BOMBYCES REARED IN 1884.

BY ALFRED WAILLY.

NORTH AMERICAN SPECIES.

Telea polyphemus.—The moths of this species emerged in 1883, from the 23rd of May to the 25th of June; in 1884, they emerged from the 18th of May, more than a month earlier, in consequence of the unusually warm weather we have had this season. However, in 1883, as may be seen from my report for the year 1883, three pairings of *Polyphemus* were obtained, and the rearing of the worms was very successful in the open air on small oak trees in my garden; in 1884, on the contrary, no pairings could be obtained. This species, as it has been previously stated, pairing with the greatest difficulty in captivity.

The cocoons received this year were for the most part very small, and the result, owing to these two causes, was a total failure. A fact came to my notice, which, I think, deserves to be recorded; a cocoon of the rearing of 1883, which had been overlooked and left all the winter, spring and summer, in the garden, produced a male moth, which emerged on the 4th August, forty-six days after the emergence of the last American *Polyphemus*, in the same year 1884, warm as the season had been. This fact tends to show that if the cocoons were left in the open air, it would be impossible to rear the species so late in the season, and, therefore, that it could not be acclimatised in England, even under the most favourable conditions.

Actias luna.—With a very large quantity of cocoons, only one pairing was obtained, which was on the early morning of the 14th of June. Most of the eggs from that single pairing were bad, and the larvæ which hatched on the 1st July died within a few days. The cocoons which had been sent to me were very small, and had the appearance of being the product of worms carelessly bred and perhaps kept short of good fresh foliage. The moths emerged from the 27th of April to the 13th of June. On the 1st of August I received twenty-three fine *Luna* cocoons, of the second brood, from Brooklyn; thirteen moths had emerged during the voyage, and two of the cocoons had died. From the eight remaining cocoons, excepting one, all the moths were large and fine, and three pairings were obtained, one male having paired twice, a very different result from the one I had with the first cocoons sent. The moths began to emerge on the 1st of August, the same day the box of cocoons had arrived, and they continued to emerge up to the 6th of the same month. The first pairing took place on the 3rd, the second on the 5th, and the third on the 7th August. The first larvæ hatched on the 13th and 14th of August; they commenced spinning their cocoons from the 28th of September and continued till the 18th of October, when they all were in cocoons. The larvæ bred in captivity in the house, thrived remarkably well on walnut leaves, and there was no case of fatality. The cocoons obtained are very fine, and much larger than the first I had received from America.

Callosamia promethea.—As in previous years, I received a large quantity of cocoons of this species, and the moths emerged from the 23rd May to the 17th of July; in 1883, they emerged from the 25th of June to the 16th of July. I note these dates to show that several species emerged much earlier in 1884 in consequence of the warmer weather. A great many pairings were obtained, and the worms placed in the open air on lilac trees thrived this year very well, commencing the formation of the cocoons on the 25th of September.

Platysamia cecropia—Moths emerged this year from the 13th of April till about the end June, more than a month earlier than in 1883. Many pairings were obtained, but only a few larvæ were reared, and that for the purpose of comparing them with those of a hybrid species, *Ceanothi-cecropia*, of which I shall speak presently.

Platysamia ceanothi (*Californica*).—In my report on silk-producing bombyces for the year 1880, a short article appeared on this species, of which I had obtained two pairings, and reared the larvæ up to the third stage only, losing them before they had reached the fourth stage. This year (1884) I had about 20 *Ceanothi* live cocoons, the moths of which emerged from the 22nd of May to the 13th of July. No *Ceanothi* pairings were obtained, but on the 5th of June, a female *Ceanothi* paired with a male *Cecropia*, and another similar pairing took place on the 22nd of June; 229 eggs were obtained from the first pairing, and 228 from the second. On the 8th of June a pairing took place between a male *Ceanothi* and a female *Cecropia*, but the eggs obtained from this pairing did not hatch. On the contrary, the eggs from the two first pairings were not only fertile, but they produced larvæ which grew and thrived remarkably well. Unfortunately, I have a disaster to record. The larvæ, when at the second stage, were reared in the garden on branches of apple trees and willows where, after growing to the third and many to the end of the fourth stage, they were all destroyed by earwigs, which had introduced themselves in the muslin bags which I had placed round the branches on which the larvæ were feeding Some of these splendid larvæ, when in the fourth stage, were exhibited by me, with others, at the monthly meeting of the Entomological Society of London, on the 6th of August.

The larvæ from the pairing of the 5th of June, hatched from the 26th of June; those from the pairing of the 22nd of June, hatched from the 6th of July, six days earlier than the first, owing to the higher temperature.

I must mention that, when the female *Ceanothi* paired with the male *Cecropia* moths, there were in the cages male *Ceanothi*, and I think, I now have cause to believe that I should have had some success with the pairings of *Ceanothi* moths among themselves, if the cages had been placed in the open air instead of being left in a room; *Cecropia* is a much stronger species, which is not much affected by surrounding circumstances.

The principal difference between the larvæ of the hybrid *Ceanothi-cecropia* and those of *Cecropia* was that in the hybrid, in third and fourth stage, there were six dorsal red spines instead of four as in *Cecropia*; some larvæ, in fourth stage, had the dorsal spines nearly of a uniform colour, From my report for 1880, it will be seen that the larvæ of *Ceanothi* have, in the third stage, all the dorsal spines or tubercles of a golden yellow colour; those of a hybrid between *Ceanothi* and *Gloveri* had orange-red dorsal spines. In other respects, the larvæ of the various species are very similar, being very closely allied. I very much regret the loss of the hybrid larvæ, as I was anxious to see what cocoons and moths would be

obtained, and, above all, to know if the crossing of *Ceanothi* with *Cecropia* would reproduce *Gloveri*, a species which partakes of both *Ceanothi* and *Cecropia*. Since writing the above, I have received a letter from Mr. C. F. Johnson, of Nottingham, who has successfully reared some hybrid larvæ of *Ceanothi-cecropia*, and he has sent me two cocoons, one of which, although larger, is somewhat similar to the *Ceanothi* cocoon, the other looks like a *Cecropia* cocoon. One of my French correspondents also has been successful in rearing the larvæ of this hybrid, and I hope to receive a few cocoons.

Ceratocampa (*Eacles*) *imperialis*.—In my report for the year 1881, an article may be read on this interesting North American bombyx, in which are described the egg, the pupa, the moth, and the larva in its various stages. The larvæ of this species, which I successfully reared in 1881, had six stages.

On the 5th of February, 1884, I received from Philadelphia seventeen pupæ of *Imperialis*, in very good condition, but several of them were afterwards attacked by dipterous parasites. Later, on the 26th of April, I received fifty-seven more pupæ from New York. These, unfortunately, had been placed in very damp moss; and, having been a long time on their journey to England, about forty died, no doubt on account of the excess of moisture in the boxes containing the pupæ. From the remaining live pupæ sixteen moths emerged from the 3rd of July to the 26th of the same month—twelve females, and three males only. The first moth (a male) emerged five days before the others, and was therefore useless for reproduction. From the 10th of July to the 16th, the moths continued to emerge without any interruption, but the last, a female, emerged on the 26th of July. I only had two male moths available for reproducing the species. The second male, which emerged on the 11th of July, paired three times; the third and last male, which emerged on the 15th of July, was a fine specimen, but it refused to pair, although it had three splendid mates. The first pairing commenced early in the evening of the 12th, and was terminated on the 13th in the evening, lasting, therefore, about twenty-four hours; the second pairing, which took place shortly after the first, was over on the evening of the 13th, and the third, very early in the morning of the 15th of July. The ova obtained from these three pairings with the same male were all fertile, but the larvæ of the third brood seemed to me weaker than those of the other two pairings. The larvæ hatched from the eggs of the first two broods were of the same size, and were equally active, but I was this season unable to rear any of these interesting larvæ. From the first pairing I obtained 126 eggs, from the second, 132, and from the third, a much smaller number, which I do not find marked down in my book. The eggs rom the first two pairings commenced to hatch on the same day, the 2nd of August; those from the third pairing on the 6th of August.

I have not, as yet, heard of the result obtained by the rearing of this species from all the correspondents who had eggs or larvæ, but two of them have been successful. Mr. H. Wolff, of Breslau, Germany, obtained *Imperialis* larvæ, measuring from 7 to 10 centimetres, and pupæ five centimetres in length. The larvæ were fed on pine.

Mr. Adolphe Weniger, of Islington, a young entomologist, who shows the greatest skill in the rearing of exotic and native lepidoptera, has not only reared the *Imperialis* larvæ with the greatest success, but also several other difficult and delicate exotic species, and this was done in his house in a populous part of London, by adopting a peculiar plan of breeding. I was surprised to see the extraordinary success with the system of rearing which he had adopted. The larvæ were bred in an immense glass case previously made for growing ferns, and the case was heated and kept to the same high temperature by means of a large lamp containing petroleum oil. On the top of the lamp was placed a large saucer containing water, the steam of which over the burning oil, filled the case with a warm moisture, together with the strong fumes of the petroleum oil. Ventilation, when required, could be given by the opening of two small windows placed on opposite sides of the case. How the larvæ could live and form their cocoons and pupæ in this atmosphere was most wonderful, but a fact it was, and the larvæ thrived and grew with extreme rapidity in these fumes of petroleum, as if they were beneficial instead of being injurious to them. In 1883, 17 larvæ of *Attacus atlas*, hatched on the 10th of July, and reared in that case, commenced to form their cocoons on the 11th of August, and the moths emerged fourteen days after. Twenty-two moths were obtained, three males and nineteen females, but no pairing took place.

This year (1884) a few larvæ of *Imperialis*, one of the species reared by this same system, underwent their changes as follows:—Larvæ hatched on the 6th of August, second stage on the 12th, third on the 17th, fourth on the 22nd, fifth on the 28th of August. Pupæ were formed on the 14th and 15th of September. The larvæ, it will be observed, only had five ages instead of six, as was the case with the larvæ I reared in 1881, but strange as it may appear, this fact has been observed with other species. Mr. Weniger fed his *Imperialis* larvæ on lime tree branches.

Larvæ of a common British bombyx, *Chelonia caja*, bred under the same conditions, thrived remarkably well; they hatched on the 26th of July, and after six moults they pupated on the 22nd of August, the moths emerging a few days after. The moths, although somewhat smaller than those obtained in nature, were very beautiful and perfect. In a state of nature, larvæ of *A. caja*, hatched at the end of July, would have hybernated and would have pupated in May or June, and the moths would have appeared in June or July of 1885.

Larvæ of *Antheræa mylitta*, another species reared in that heated glass case, thrived and grew with the same rapidity as the species above mentioned. Eggs

laid on the 28th of August, hatched in the case on the 4th of September, the larvæ commencing to form their cocoons on the 12th of October at the fifth stage instead of the sixth; the two remaining larvæ, however, had the appearance of going to moult for the fifth time. I shall hear later on of the ultimate result. Whether this plan of rearing would be successful for the reproduction of the species in the following year is a question which I should not be inclined to answer in the affirmative, but it has been successful with several species for rearing the larvæ and obtaining pupæ and perfect specimens of the moths, which is all that is wanted to know the insects in their various states.

In my report for the year 1881, it will be seen that I suspected the *Imperialis* larvæ of being carnivorous, and although this year no mention has as yet been made to support or to contradict this statement by the persons who have reared this species, I will quote what one of my American correspondents, Mr. E. F. Hitchings, says on this subject:—"I was much pleased to see the account of *Ceratocampa imperialis*. I have had some small experience with the larvæ, which I will relate. In the fall of 1881, I obtained several almost full-grown larvæ, and put them in a box with plenty of pine and button wood leaves; in a few days I noticed that several had disappeared, and on examination found the skins with the juice all extracted; they were all of a large size, and I found one or two of these skins held in the manner described by you. I then put in several full-grown larvæ of *Telea polyphemus*, and they were disposed of in the same way; this led me to conclude that they were carnivorous. In 1882, I noticed the the same thing; last season all the larvæ I saw were feeding on pine. The larvæ here are generally dark green; I have seen very few reddish brown."

(To be continued).

BURMESE ARTS.

A "Description of the principal Art Handicrafts and Manufactures of British Burma" has recently been printed. The Burmese are here described as an artistic people, although no handicrafts have attained excellence except, perhaps, those of the silversmith and wood-carver. Most Burmans are, however, able to draw spirited though conventional representations of animals and foliage. The art workmen are contented with bold, rough work, and are generally indifferent to all attempts at finish or sound workmanship. Occasionally, individuals are found who show considerable originality and artistic perception, and are capable of designing and finishing their work in first-rate style; but none of the skilled artisans of Burma equal those in some of the great cities of India. "Perhaps no better example of the effects of this infirmity could be given than that of weaving. This is, perhaps, the oldest art in the province; it has been practised in every house and hut throughout the country from time immemorial. Supplies of cotton and silk are to be had at almost every man's door; while perhaps there is no race in the world more fond of brave attire, or amongst whom the poorest gives such extraordinary prices for a cunningly-woven garment. Yet the best weavers in the country—in fact, the only persons who produce the costly and elaborate *pasos* and *thameins* which are so much prized, and which produce such a pleasing effect at the great pagoda festivals, are of alien race, the descendants of slaves captured and brought to this country from Manipur by one of the Burman kings."

The art handicrafts are described under eight heads, as follows:—1. Artists, including funeral pyre makers. 2. Brassfounders. 3. Carvers in Wood. 4. Carvers in Ivory. 5. Gold- and Silversmiths, including workers in niello. 6. Kalaga makers. 7. Lacquer workers. 8. Lapidaries.

Artists' work is classified under—1. Pictures, such as portraits, landscapes, &c. 2. Funeral pyres and decorative work generally. 3. Mask making. The colours used are in powder, and are purchased in the bazaars; most of them are sent from England, the exception being indigo, yellow ochre, and vermillion, from Mandalay. Cotton fabric is used instead of canvas, and the size is made of lime and tragacanth. The artists make their own brushes, of the hairs from the inside of the bullock's ear. In making funeral pyres besides the above materials, bamboos and thin planks are used for the frame, also different coloured papers and cloths, gold and silver tinsel paper, pieces of looking glass, &c.; and for making masks clay and chopped straw are added. The majority of Burmans seem to draw by intuition, and those among them who have been trained to any art are masters of the pencil, although they have little idea of perspective or of the balance of light and shade. Although the details are conventional, the general idea is the creation of the workman. It is not, therefore, surprising that the artists of the country produce wonderfully good pictures of dramatic and mythical incidents, full of life and humour. Landscape painting is in its infancy, but the artists are anxious to learn. On the whole, it is said that pictorial art in Burma is progressing, and the artists are conscious that they have much to learn, so that there is every hope that they will rapidly improve. The pictures are drawn on cotton, stretched tightly on a wooden frame. The cotton is first washed over with size, after which the subject is outlined in charcoal, and, when correct, in red ochre, after which the colours are laid on as required. The back ground is generally a flat wash of dark colour.

With regard to the decoration of funeral pyres, a considerable amount of attention seems to be given to them, though they are destined for destruction by fire; some of the paintings are extremely grotesque.

The profits obtained by artists vary according to their reputation, thus a portrait painter in Moulmein

commands as much as Rs. 80 to Rs. 120 for a single likeness, and the best decorators in Rangoon earn Rs. 60 a month. An ordinary artist makes about Rs. 30 a month.

Brassfounders are classified under three heads, namely—(1) makers of images of Gotama; (2) makers of large bells for pagodas, small bells to hang to the ti of a pagoda, and open and closed cattle bells; (3) makers of flat, crescent-shaped gongs, used for religious purposes. The following description is given of the process of casting:—"A rough solid core of the image to be cast is first made in clay, somewhat freely mixed with sand and paddy husk. A composition, made of beeswax 10 parts, resin 7½ parts, to which is added earth oil, is melted down, and in its liquid state thrown into a large shallow basin of water, and, on cooling, forms a layer of uniform thickness on the surface. The composition is then plastered on the clay case, and with the aid of knives and chisels is carved into the desired shape in all its detail. The composition is now in its turn covered entirely, with the exception of a hole on the crown of the head, with a rather thick layer of clay, without any attempt to adhere to the lines of the model. When the outer layer of clay is perfectly dry, the model is heated to allow the composition to melt and run out of a small hole provided for the purpose at the foot of the model. When it has all run out the hole is closed with clay, and the molten metal, supplied from furnaces close at hand, poured in at the crown of the clay mould. The casting is then left to cool for a day or so, or louger according to its size, when the outer and inner mass of clay is removed. The image is next finished off with files, sand-paper, and polished with steel burnishers."

Of wood and ivory-carvers it seems there were, of the first, in 1881, forty in Henzada, and at least a dozen in Rangoon; besides which it is estimated that there mnst be one or two hundred men in the province who have no other occupation, to say nothing of those who combine carving with another trade. Of the second, or ivory-carvers, it is said there are three master carvers in Moulmein, two or three in Rangoon, and a few more scattered throughout the country. Wood-carving has a very extensive range of variety of character, both of ornamentation and merit. The most characteristic work in foliage and figures is to be found in the Buddhists' monasteries; some of the work is remarkably beautiful, as much for the delicacy of the curves as for the lightness and grace of the open tracery. An Institute of Industrial Arts has been established at Rangoon, to develop this industry, and it is hoped that a foreign demand may spring up. In the rougher kinds of work, the designs are drawn on the wood itself in chalk or charcoal, and are chiselled out very rapidly by the workman. For the better kind of work the designs are drawn with pencil on paper, and placed on the wood. The larger holes are gouged and chiselled out, and the rougher work done, by the pupil, the finishing being done by the master. The foliage is conventional, but a good workman is exceedingly particular in obtaining easy flowing curves, and in working out every detail in strict accordance with truth and the principles of the art. Each leaf, bud, or flower has its proper shape, and no vague mixture of the characteristics of another style is allowed. The price of labour for wood-carving ranges from 12a. to Rs. 20 a square foot. Very good work may be obtained for Rs. 5. A carved figure or statue 4½ feet high, properly painted, of first-class work, may be obtained for Rs. 60.

A journeyman carver obtains Rs. 1-8-0 a-day, and the best master carvers obtain Rs. 60 a month, which is the average rate obtained by any skilled master mechanic or tradesman. The following description of the method of working by ivory-carvers will explain that exquisite work so often seen and admired by Europeans. "A curious and intricate effect is obtained by Burmese workmen for dâ-handles and table ornaments. The outside of the specimen is carved with foliage and flowers, through the interstices of which the inside is hollowed out nearly to the centre, where a figure is carved *in situ*. The figure looks as if it had been carved separately and inserted into a flowery bower, but closer examination shows that this is not the case, and the men may be at any time seen carving the figure through the opening of the tracery." The elephants' tusks are obtained from Upper Burma and Siam. There is no fixed rate for this kind of work, but it is not considered so remunerative as that of the other artists of Burma.

Under the head of gold aud silversmith it is stated that 7,272 persons are recorded officially as working at these trades, and engaged as dealers in precious stones, in gold and gold leaf, and as lapidaries. The highest wages are obtained in the large towns, and the best workmen are consequently attracted; every village, however, greater than a hamlet, has its goldsmith and silversmith. The best work is produced in Rangoon, and after this in Moulmein, Shwegyin, Prome, and Thayetmyo. In the filagree ornaments, made by goldsmiths, the burnished gold retains its proper colour, but the other gold is dyed red with tamarind juice, a barbaric custom to which the Burmese cling tenaciously. "The reason given is that no other metal but gold will assume this particular ruddy colour when treated with tamarind juice; it may, in fact, be regarded as the hall-mark of Burmese jewellery." Various articles of personal adornment, in a great variety of forms, are made, and most of the gold used is said to be obtained by melting down English sovereigns; Chinese gold leaf, coming through Upper Burma, is employed when purer gold is required. The leaves are about 3 inches square, and are of three qualities, the best being said to be quite pure. A small quantity of pure gold is also obtained from the Shan States and Bangkok, a very soft variety, having a slightly green colour.

Gold leaf is sent from England in some quantity.

To dye an ornament red, it is scrubbed with a wash composed of one part of gunpowder, half part of salt, and one part of alum, to which water is added, and boiled for half an hour. This clears the gold, and prepares it for the dye, which is made of tamarind, sulphur, salt and water, in proportions known only to the master goldsmiths. The ornament is boiled in this for about an hour. The best Burmese goldsmiths' work is stated to be equal in design and finish to that of Bond-street.

The silver work of Burma is much thought of by connoisseurs all over the world, and under the guidance of Europeans it is being improved, while the national characteristics are jealously preserved. The work is hammered, embossed, chased, and carved, and sometimes cut into open tracery, though it is all made in the same way, it can be applied to any shape, and European patterns are often covered with Burmese work, but the native demand is entirely for such simple shaped articles as round bowls without cover or legs, betel boxes, small oval lime boxes, and such like. More intricate shapes are made for use in the palace at Mandalay. The Burmese artist treats silver in the right way, obtaining the greatest possible effect that the nature of the material allows.

The method employed by silversmiths in these works is—when giving his order the customer pays for the silver of which the bowl, for instance, is to be made, and the rupees are melted down in a crucible over a charcoal fire. If, however, the work is to be very good, better silver is bought, and is purified over a flaming fire in a flat burnt clay saucer. When pure, the melted metal is allowed to cool in the saucer which serves as a mould to produce a plate flat on one side and convex on the other about $\frac{1}{2}$ in. or $\frac{3}{4}$ in. thick. The silver plate is then gradually beaten out on a small iron anvil with an iron hammer until it is of the full diameter of the bowl to be produced. Throughout this process, and until all the hammering is over, it is from time to time dipped in cold water to preserve its ductility. The right diameter being attained, the edge or lip is raised by hammering with a straight edged hammer at an angle of 45°, and when the lip has been raised all round, the operator begins beating on the bottom in a narrowing spiral line until the centre is reached, when he steadily works outwards and again inwards, and so on. This process causes the tip or edge to rise, and it is continued until the full weight required has been obtained. The bowl is then beaten with a heavier hammer on a small curved iron anvil until it is of the right shape, when it appears pretty smooth, and covered with innumerable small hammer marks. The old masters gave great importance to this hammering, and it is said to be necessary, to render the silver ductile enough to withstand the severe handling it has afterwards to undergo.

A composition of earth, oil, brickdust, and resin, is next prepared, and melted into the small bowls, and a short stick is thrust in to serve as a handle. In large bowls an earthenware jar, tapering towards the bottom, is placed abou half-way down the bowl, and the space between the two is filled up with the composition.

The lines dividing the surface horizontally are drawn with a pencil and then with a graver; in the best shops this is done with a lathe. The surface is divided into the various "houses" or portions for figures, and the borders and the flower work drawn with a pencil, and marked out with a graver. The master generally draws a small portion as pattern, which is repeated by his pupils; he also draws the figures in pencil unless he has a skilled pupil. When this entire pattern has been engraved in line the first embossing takes place, by which all the parts to be lowered are punched in, and recede into the pliant composition, which also forces out those portions which are to be in relief. The composition is next melted out, and those parts which are not in sufficiently high or sharp relief are punched outwards from the inside. After some further slight manipulations the bowl is handed over to be chased, carved, and cut about until every face has expression, all clothes texture, until the leaves curl over round the gracefully twining tendrils, and the whole composition receives those last touches which show that the design has, from the beginning, been clear in the creative brain of the artist. When the work is finished, it is boiled in a solution of alum for half an hour, and then brushed with soap and cold water. The flower work is burnished with small brass wire brushes, and the large smooth portions with stee burnishers, and the whole rubbed with white enamel beads. In many compositions, such as centrepieces, vases, and candlesticks, figures in the round are introduced. The figure is first shaped and carved in a composition of two parts of beeswax and one part of resin. When correctly modelled, the figure is coated over with a thin layer of fine clay, well kneaded and mixed with chopped straw, and afterwards with a thicker layer of ordinary clay. The mould is baked in the fire, the wax melts, and runs out through a hole left for the purpose, and the clay becomes as hard as a brick. Ths melted silver is run in, and when cool, the mould is broken, and the silver figure is patched and corrected as required. The best master silversmiths are able to make a profit of 30 per cent. on the ultimate value of the work turned out of their shop, provided there is sufficient work to keep all hands busily engaged. This is not, however, often the case, and the trade is not a paying one. The leading artists are devoted to their art, and are quite content if they gain enough to live on, provided that they keep their position at the head of the craft. Work is paid for by weight.

Many of the Burmese silversmiths are proficient in the art of Niello work, though but few are fond of it, because it entails working over a hot furnace, and in sulphurous fumes. The design appears as if drawn in silver outline on a black ground. The articles made are cups, lime boxes, plates, knife handles, &c., and are all quite smooth, with a good polish.

Lacquer Ware Makers.

The lacquer ware used in British Burmah is said to be of two kinds, one in which the article is made of basket work, and then lacquered, and the other in which the article is made of wood, and coated with lacquer. All the basket lacquer ware comes from Upper Burma, where it is a very important trade. In British Burma the manufacture of lacquer ware is confined to wooden articles, as platters, boxes, bowls, &c., the general turn out of which is so good that a demand has arisen for tables and panels of a similar design. The lacquer is made by mixing the sap of *Melanorrhœa usitatissima* with vermillion when a red lacquer is required, or by using the sap alone when a black lacquer is wanted. The wooden articles are made perfectly smooth, and all cracks and holes are stopped with the lacquer itself mixed with teak-wood sawdust; when sufficiently hard, and the whole surface quite smooth, the raw lacquer from the tree is rubbed well over the article with the bare hand, by which means any grit is easily detected and removed, and the article is put in a cool and dry place for three or four days, when a thick coating made of *Melanorrhœa* sap, rice water, and paddy husk ashes, is laid on, and the article again put aside to dry and harden, after which it is thoroughly smoothed down and a coating of black or red lacquer finishes the process.

Of other art workers in Burma, the operations of Kalaga-markers, or those who work in cloth and silk or state dresses, such as appliqué work and gold and silver lace decoration, are described, as also those of the lapidaries or stone polishers, besides which, under the head of manufactures, some very interesting and novel facts are recorded.

THE MECHANICAL TREATMENT OF FIBROUS PLANTS.

Several trials of machines for decorticating the stems of the rheea and other fibrous plants have taken place in India at various times within the present century, in competition for a reward of £5,000 offered by the Indian Government. The prize, however, was never carried off, owing to the machines submitted for trial having failed to fulfil the conditions laid down. Another competitive trial took place last October, at Calcutta, and one of the competing machines has been awarded a prize of Rs.2,000. It is stated that the reason for the prize being so much smaller in amount than in the past, is that the conditions under which the recent trial took place were less stringent than formerly. The competition was ordered by the Government of Bengal, with a view to the introduction into India of a cheap, simple, and portable fibre-extracting machine. Nine machines were entered for trial—namely, one by M. Berthet, manufactured by MM. Talpin, frère, et Cie, of Rouen; two by Mr. Hatti Borooah, a native gentleman of Upper Assam; four varieties of Pownall's flax scraper, Cantwell's process, and H. C. Smith's machine, manufactured by Messrs. Death and Ellwood, of Leicester. This last consists of an iron drum armed with beaters, and made to revolve on a horizontal axis, against a feeding-table. The plants are held up against the beaters by a strong thin sheet of water, which is projected upwards from under the feed-plate. The stems being fed into the revolving drum, the beaters smash the woody portions of the stems or leaves, disengage the pulpy matter, and draw the crushed stem under the drum. The sheet of water then pressing the plants against the beaters, a beating and scraping action continues, and the water, acting as a cleanser as well as an elastic cushion or backing to the fibre while it is struck with the beaters, insures a thorough cleaning. By it Bondhendras (wild bhendi), with its large amount of mucilage, was worked out with the greatest ease. Rheea, it is stated, was cleaned better than any produced in any trial hitherto held in India. The other plants also yielded fibres which are said to have been far superior to any samples to be had there.

The Lieutenant-Governor of Bengal announces that he accepts the finding of the committee, and the following is taken from the Government Resolution:—"The mechanical working of this machine appears to have been rapid and effectual, and the further question whether it can be profitably introduced into Bengal may well be left to be decided by the commercial public, who have already shown considerable interest in the trials. The value of the fibres extracted, and the uses to which they can be put, are also matters to be dealt with by experts and commercial men in the course of their ordinary business, and no further action on the part of Government appears to be called for. Should it, however, be afterwards found that the facts ascertained in the recent trials are not complete enough to enable the mercantile public to form a fair judgment of the commercial prospects of the successful machine, further trials may be conducted under the superintendence of the Agricultural Department. In the meantime, in accordance with the recommendation of the committee, the Lieutenant-Governor has much pleasure in awarding a prize of Rs. 2,000 to the General Fibre Company of London, for Messrs. Death and Ellwood's machine.

The working of the machine was explained by Dr. Forbes Watson, in a paper read before the Society of Arts, Dec. 10, 1883, on "The Preparation and Use of Rheea Fibre" (*Journal*, vol. xxxii., p. 66).

ORANGE CULTIVATION IN BRAZIL.

Consul Andrews, of Rio de Janeiro, states that oranges appear to flourish in all parts of Brazil, large quantities of which are consumed in the country, and several millions annually exported to the neighbouring countries, Uruguay and the Argentine Republic. As Pernambuco is distinguished for its

pine-apples, so is Bahia for its large, sweet, and delicious oranges, the favourite variety being the Umbigo, which is without seeds. It begins to ripen about May and lasts till September. Oranges are also produced extensively in the vicinity of Rio de Janeiro, the most common and popular kind being the Siletta, which, when ripe, has a sweet and delicate flavour. Another variety which is much used, is the Tangerina. This is smaller than the Siletta, with deep orange-coloured skin that breaks easily when peeling, and has an aromatic odour; it contains many seeds, and ripens about the same time as the Siletta. Orange orchards, in which the fruit is grown for the market, are generally situated on low and sandy land, the selection being influenced by the facilities of water transport. The young trees are planted in the months of April and May, though sometimes they are planted in March, and occasionally in February if the month be rainy. They are planted about 15 feet apart, and begin to bear in about five or six years, yielding twenty to thirty oranges each, and then continue to increase for ten years afterwards when they are in full bearing and produce 200 to 300 oranges per tree. They remain fruitful for more than thirty years, and in the most favourable circumstances a tree will produce 1,000 oranges in a year. The oranges are gathered by knocking them from the trees with a pole, so that a piece of the twig two or three inches in length adheres to the orange. They are not gathered till they have lain on the ground a few hours in the sun to dry. After a tree is full grown it is pruned about twice a year. It is estimated that the annual cost of cultivating and attending 1,000 orange trees in Brazil is about £14.

Obituary.

COLIN MINTON CAMPBELL, of Woodseat, near Uttoxeter, Staffordshire, principal partner in the firm of Messrs. Mintons, died on Saturday, 7th inst., after a long illness. He was the eldest son of Mr. John Campbell, of Liverpool, by marriage with Mary, daughter of the late Mr. Thomas Minton, of Stoke-upon-Trent, and was born at Liverpool in 1827. He sat in the House of Commons in the Conservative interest, as the colleague successively of Sir Charles Adderley (now Lord Norton), and Mr. Robert Hanbury, from 1874 down to the dissolution in 1880, when he retired from Parliamentary life. Mr. Campbell invented a new method of producing durable mural paintings by fictile vitrifaction, which was described by Mr. Alan Cole, in a paper read before the Society of Arts, on December 14th, 1870 (*Journal*, vol. xix., p. 65). Mr. Campbell was elected a member of the Society of Arts in 1860.

General Notes.

LADIES' SANITARY ASSOCIATION.—Mrs. Shiel will deliver a course of twelve lectures on Physiology and the Laws of Health, before this Association, at 22, Berners-street, Oxford-street, W. The first lecture is fixed for February 26th, and the course will be completed on May 21st. The following are the subjects of each lecture:—1. Prevention of Disease. 2. The Framework. 3. The Muscles and Skin. 4. Circulation. 5. Respiration. 6. Ventilation and Disinfection. 7. Clothing. 8. Food. 9. Digestion and Nutrition. 10. Nervous System. 11 & 12. The Senses, Sight, Hearing, &c.

PRECIOUS METALS IN 1884.—The annual statement of precious metals produced in the United States and Territories west of the Missouri River during 1884, published by Mr. John J. Valentine, the vice-president and general manager of Wells, Fargo and Co., shows aggregate products as follows:—Gold, $26,256,542; silver, $45,799,069; copper, $6,086,252; lead, $6,834,091. Total gross result, $84,975,954. California shows a decrease in gold of $944,703, and an increase of silver of $513,597. In Nevada, the Comstock shows an increase of $1,668,524; Eureka district shows a decrease of $123,152. In the total product of the State, there is an increase of $117,318. Montana shows a considerable increase. Colorado and Arizona show a decrease from the production of 1883.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

FEBRUARY 18.—"Malt-making." By H. STOPES. Lord ALFRED S. CHURCHILL will preside.

FEBRUARY 25.—"Past and Present Methods of Supplying Steam Boilers with Water." By W. D. SCOTT MONCRIEFF, M.Inst.M.E.

MARCH 4.—"The Evolution of Machines." By Professor H. S. HELE SHAW.

MARCH 11.—"Exploration, and the Best Outfit for such Work." By Major-General the Hon. W. FIELDING.

MARCH 18.—"The Rivers Pollution Bill." By J. W. WILLIS-BUND.

MARCH 25. "Introduction of the Beet Sugar Industry into England." By Colonel Sir FRANCIS BOLTON.

INDIAN SECTION.

Friday evenings at Eight o'clock.

FEBRUARY 20.—"The Teak Forests of India and the East, and our British Imports of Teak." By P. L. SIMMONDS. Colonel MICHAEL, C.S.I., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings at Eight o'clock.

FEBRUARY 24.—"The Spanish Gold-fields and the Mines of Rio Sil." By WILLIAM SOWERBY.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings at Eight o'clock.

FEBRUARY 26.—"Tempered Glass." By Dr. FREDERICK SIEMENS. Sir FREDERICK BRAMWELL, F.R.S., Pres. Inst.C.E., will preside.

CANTOR LECTURES.

Monday Evenings at Eight o'clock.

The Third Course will be on "The Distribution of Electricity." By Professor GEORGE FORBES, M.A., F.R.S.E.

LECTURE III. Feb. 16.—Series mains.—Multiple arc series.—Methods which have been used.—Modifications proposed.—Economy of this system.—Supposed danger of high potentials.—Three wire system.—Accumulators used in two ways: (1) charge and discharge in series; (2) charge in series, discharge separately.—Secondary generators.—Example of central station lighting now accomplished.—The problem an engineering problem with all the data for calculation.—Conclusion.

The Fourth Course, "Chemistry of Pigments." By J. M. THOMSON, F.R.S.E., F.C.S., Lecturer on Chemistry at King's College, London.

LECTURE I. Feb. 23.—Introductory. Nature of Colour. Division of Colours. White Pigments. Deleterious actions on such Pigments. Methods of counteracting such actions.

LECTURE II. March 2.—Chemistry of Blue, Yellow and Red Mineral Pigments. Certain Organic Pigments. Special Pigments.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 16...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. George Forbes, "The Distribution of Electricity." (Lecture III.)

British Architects, 9, Conduit-street, W., 8 p.m. Mr. R. Neville, "Roof Covering."

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m. Rev. T. Foulkes, "The Sallavas of Southern India."

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Dr. Blackett, "The Evolution of Religion."

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. G. Massee, "New Discoveries in the Motion and Variation of Plants."

TUESDAY, FEB. 17...Royal Institution, Albemarle-street, W., 3 p.m. Prof. Sidney Colvin, "Museums and National Education." (Lecture I.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Mr. B. Baker, "The Metropolitan and Metropolitan District Railways." 2. Mr. J. Wolfe Barry, "The City Lines and Extensions (Inner Circle Completion) of the Metropolitan and District Railways."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m. Sir Richard Temple, "Population Statistics of China."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Zoological, 11, Hanover square, W., 8½ p.m. 1. Mr. F. E. Beddard, "The Structural Characters and Classification of the Cuckoos." 2. Mr. M. Jacoby, "Descriptions of the Phytophagous Coleoptera of Japan, obtained by Mr. George Lewis during his second journey from February, 1880, to September, 1881." (Part I.)

WEDNESDAY, FEB. 18...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. H. Stopes, "Malt-making."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Dr. C. H. D. Buys-Ballot, "How to detect the Anomalies in the Annual Range of Temperature." 2. Mr. D. Wilson Barker, "Cloud Observing." 3. Mr. William F. Stanley, "A Suggestion for the Improvement of Solar Radiation Thermometers."

United Service Institution, Whitehall-yard, S.W., 3 p.m. Captain C. C. Fitzgerald, "Naval Education."

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. Thomas Morgan, "The Roman Baths of Bath." 2. Rev. G. F. Browne, "The Ancient Cross in Leeds Church." (Conclusion.)

Hospitals Association, 1, Adam-street, Adelphi, W.C., 8 p.m. Dr. P. Murray Braidwood, "Hospital Ships."

THURSDAY, FEB. 19...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Rev. A. E. Eaton, "Recent *Ephemeridæ* or May Flies." (Part III.) 2. Mr. W. Mitten, "Mosses of the Genus *Fissidens*." 3. Professor Duncan, "Structure of Ambulacra of Living *Diadematidæ*."

Chemical, Burlington-house, W., 8 p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. H. B. Wheatley, "The Topography of London." Lecture II. "After the Fire."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, "The New Chemistry." (Lecture VI.)

Historical, 11, Chandos-street, W., 8 p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Special Lectures on "The Theory and Practice of Hydro-Mechanics." (Lecture II.) Dr. William Pole, "Water Supply."

FRIDAY, FEB. 20...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. P. L. Simmonds, "The Teak Forests of India and the East, and our British Imports of Teak."

Geological, Burlington-house, W., 1 p.m. Annual Meeting.

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Dr. W. Huggins, "The Solar Corona."

Philological, University College, 8 p.m. Dr. W. Stokes, "Old Irish Declensions."

SATURDAY, FEB. 21...Royal Institution, Albemarle-street, W., 3 p.m. Mr. G. J. Stoney, "The Scale in which Nature works, and the Character of some of her Operations." (Lecture IV.)

Journal of the Society of Arts.

No. 1,683. Vol. XXXIII.

FRIDAY, FEBRUARY 20, 1885.

All communications for the Society should be addressed to Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The third and last lecture of the course on "The Distribution of Electricity," was delivered on Monday evening, 16th inst., by Professor George Forbes, who continued his description of the system of multiple arc series; and after noticing the three-wire system, directed attention to the use of accumulators, and the future that may be looked for from the use of secondary generators. In conclusion, Professor Forbes explained the engineering problem connected with lighting from a central station. The lecture was illustrated by lamps, lent by the Edison and Swan Company, and other apparatus.

A vote of thanks to the lecturer was carried unanimously on the motion of the Chairman (Mr. W. H. Preece, F.R.S.).

The lectures will be printed in the *Journal* during the summer recess.

PRACTICAL EXAMINATION IN VOCAL AND INSTRUMENTAL MUSIC.

The next Examination in London will be held by Mr. W. A Barrett, Mus.Bac. (Oxon.), at the House of the Society of Arts, 18, John-street, Adelphi, W.C., during the week commencing 8th June, 1885.

Full particulars can be obtained on application to the Secretary

Proceedings of the Society.

APPLIED CHEMISTRY & PHYSICS SECTION.

Thursday, Feb. 12, 1884; W. H. Perkin, F.R.S., President of the Chemical Society, in the chair.

The paper read was—

THE PRODUCTION OF AMMONIA FROM THE NITROGEN OF MINERALS.

By George Beilby.

There is probably room for considerable difference of opinion as to the origin of combined nitrogen in the early stages of the world's development, but it will be pretty generally admitted that the available sources of combined nitrogen at the present day are all, either directly or indirectly, organic. Cyanogen compounds and their derivatives, ammonia salts and alkaloids, nitrates and the oxides of nitrogen, are invariably produced from nitrogen which has previously existed in the combined form in organic tissues. The vast stores of such nitrogen contained in beds of coal and peat must, as far as we can see at present, remain in the future the main source from which the supplies for industrial use will be obtained. Owing to the abundant supply of natural nitrate of soda in Chili and elsewhere, it has hitherto been quite unnecessary to devise any artificial process for the production of nitric acid or nitrates. The guano deposits of South America were for many years the chief source of the ammonia salts used in agriculture, and caused the ammonia produced in gas-making to be looked on as a bye-product, only to be worked up under favourable circumstances; the industrial production of ammonia for its own sake was therefore not seriously attempted. These facts must, to a large extent, be held to account for the lack of a vigorous and rational treatment of the subject of ammonia production from the vast stores of combined nitrogen existing in the old organic deposits of the peat and coal-fields. Turning, however to the technology of cyanogen compounds, we find a much fuller record of technical research. The industrial world needed cyanides, and as no convenient natural stores of them had been provided—as was the case with nitrates and ammonia salts—cyanides had to be produced artificially.

In the researches on the manufacture of cyanides, we might fairly expect to find the germ of a rational knowledge of such of the properties of organic nitrogen as are related to its conversion into ammonia. This expectation is not disappointed; the records of the researches of English, German, and French chemists in this field are not only deeply interesting, but they are both instructive and suggestive. The earliest studies on the behaviour of the nitrogen of organic substances during destructive distillation were made in this connection, and it was then first recognised that the temperature of distillation had a most important influence on the ultimate distribution of the nitrogen among the products of distillation and the residual charcoal. Karmrodt found, in carbonising horn, that at three temperatures, ranging from a low red to a white heat, the residues contained respectively 7, 5, and 2 per cent. of nitrogen, the last resulting from the highest temperature. The significance of such a fact as this, as bearing on ammonia production, evidently did not appear to the investigators, who were simply bent on devising an economical process for the manufacture of cyanides, and to whom the inevitable production of ammonia was an evil to be as far as possible minimised.

The rapid exhaustion of the guano deposits, and the increasing consumption of ammonia salts for agricultural purposes, so acted on the ammonia market that, in the year 1879, the price of sulphate of ammonia had risen to £20 per ton. This high price occurring along with a general fall in the value of several of the commodities produced at the same time, or by the same processes as ammonia, formed a powerful stimulus to producers of ammonia to increase their output, and at the same time roused the interest of those who, like the owners of blast furnaces and coke ovens, had hitherto allowed large quantities of ammonia to go to waste. The gas companies had for years been perfecting plant for washing out the ammonia from their gas, and the increased output thereby brought about must have been very considerable. Iron and coke makers turned their attention with renewed interest to the treatment of the gases from their furnaces and ovens for the recovery of ammonia.

These efforts were directed to the recovery from the products of destructive distillation of the ammonia naturally resulting from that operation. It is now pretty generally understood that in destructive distillation, as ordinarily practised in the gas manufacture, only one-sixth to one-twentieth of the nitrogen of the material distilled is obtained as ammonia. This important fact was noted in more than one standard work on applied chemistry, but attracted no attention either in scientific or technical circles. Dr. Lunge, in his work on "Coal Tar Distillation," published so recently as 1882, quotes a table of analyses by Dr. Meymott Tidy, showing the amount of nitrogen in various coals, and comparing the possible with the actual ammonia yields of the gas companies. The result of his comparison is to show that, in illuminating gas making, only one-sixth of the total nitrogen was obtained as ammonia.

My own interest in the subject dates from 1870, when Mr. A. R. Gillespie, managing director of the Oakbank Oil Company, suggested that I should analyse all the shales then known to exist in the Midcalder field, both those which were considered worth working for the paraffin products, and those which were not. It was thought possible that some of the poorer oil shales might yet be sufficiently valuable for their ammonia to admit of their being profitably worked. The determination of the nitrogen in these shales showed that, by the process of distillation as then practised, only one-sixth of the nitrogen was obtained as ammonia. The fate of the missing five-sixths at once excited our interest, and the research was carried on till the whole was accounted for. As oil shales are practically unknown in England, a few words of description at this point may make clearer what is to follow.

The oil shales of Scotland are found below the coal measures, and are generally asociated with marls, limestones, and sandstones. The specimens before you will show you how unlike coal in appearance the shales are. They are generally of a brown or grey colour, the richer portions are tough, and cut like leather, while the poorer are stony and slatelike. They contain a very large per-centage of mineral matter, sometimes as much as 80 per cent., generally about 73 per cent. When heated to redness in a close vessel, true shales do not soften or cake, the pieces neither alter in size nor shape, but, after all the volatile matter is distilled off, the residue, or "spent shale," which is soft and black, has still the outward form of the original shale. There are four principal seams, or groups of seams, worked in Scotland; among these, one of the best defined and most extensively worked is the Broxburn shale, so called from having been first found at Broxburn, in Linlithgowshire. It is not, however, confined

to that particular district, but is at present worked at points as much as 12 to 15 miles apart. This shale was in regular use at Oakbank, in 1870, and special attention was therefore given to the study of the behaviour of its nitrogen. By the process of distillation, as practised at that date, the shale was subjected for from 12 to 20 hours to a low red-heat, in iron retorts, a current of steam being passed through the retort during the distillation. The volatile hydrocarbons and other vapours were cooled by passing through condensers. The distillate from one ton of shale consisted of about 30 gallons of crude paraffin oil, and 60 to 80 gallons of ammoniacal liquor, the large volume of the latter being due to the condensation of the steam passed through the retort. This ammoniacal liquor contained ammonia equal to about 15 lbs. of sulphate. The primary object of the use of a current of steam in the retort was to obtain a maximum yield of paraffin products, through the protective action of the steam in sweeping away the hydrocarbon vapours as they were formed, and before they could be decomposed by overheating; but it is quite certain that this use of steam increased the yield of ammonia, the gain probably amounting to 5 or 6 per cent. of the original nitrogen. The coke or residue of this shale (specimens exhibited), known as "spent shale," was, in 1870, sent to the refuse heap as of no value; but, in the three following years, the successive efforts of Mr. Wm. Young and Mr. N. M. Henderson resulted in the invention of the "Henderson Retort," in which, by means of ingenious mechanical contrivances, the exhausted residue, or "spent shale," was dropped, while still hot, into a slow combustion furnace, in which the small per-centage of carbon, associated with a very large amount of earthy matter, was made to supply a large proportion of the heat necessary for the distillation of the shale. The ash, or earthy residue, was now obtained practically free from fixed carbon, and was sent to the refuse heap.

Returning now to the researches of 1870, analysis of the "Broxburn shale" showed that it contained 0·72 per cent. of nitrogen, and that, by the system of distillation then followed, the distribution of this nitrogen among the residue and products was such that of 100 parts of nitrogen in the shale:—

17·0 parts appeared as ammonia in the watery distillate.
20·4 " " alkaloidal tars in the oil.
62·6 " " in the "spent shale."

Or, expressing these proportions in actual numbers, and calculating the nitrogen into its equivalent of sulphate of ammonia, the following results are obtained:—

One ton of shale contains nitrogen equal to 74·8 lbs. of sulphate of ammonia.	
The watery distillate contains ammonia equal to	12·7 lbs.
The alkaloidal tars in the oil contains nitrogen equal to	15·3 "
The "spent shale" or coke contaius nitrogen equal to	46·8 "
	74·8 "

The knowledge thus gained was the base from which all our subsequent researches were planned, and many efforts were made to win at least a portion of this hitherto unworked store of nitrogen. The problem which, in the light of present knowledge, seems so simple, was necessarily looked at from the oil makers' point of view. From that standpoint, the value of the paraffin products being five times that of the ammonia, efforts were most naturally directed to the simultaneous improvement of ammonia and paraffin produced. Now, the first investigation had shown that one-fifth of the total nitrogen of the shale went to the formation of complex basic substances in the oily distillate, from which they were ultimately separated by chemical treatment, and were then thrown aside as of little value, or were used as fuel. There was thus the double loss, of the nitrogen, which might have been ammonia, and the carbon and hydrogen, which might have been paraffin or oils. It was natural, therefore, that the nitrogen in the oil should first attract attention, and that attempts should be made to gain an increased yield of hydrocarbons and ammonia simultaneously. The simpler and more stable bases, piccoline pyridine, &c., were found quite refractory, except under such heroic treatment as inevitably sacrificed the hydrocarbons. By a modification of Berry's cyanide process, it was possible to convert the basic nitrogen into cyanides, but, of course, with complete destruction of the associated hydrocarbons. The more complex nitrogenous substances, on distillation tend to break up into ammonia, simpler bases, and hydrocarbons; but the proportion of ammonia obtained by a single distillation is very small.

The use of slaked lime in the shale distillation was very fully and practically tested but it was found that, at the temperature most suitable for oil distillation, no gain of ammonia was brought about. On the

other hand, the crude paraffin oil was distinctly purer and more easily refined. Though this result does not at first seem in accord with results recently obtained by the use of Cooper's coal liming process in gas-making, yet in reality the two results are not inconsistent. In the case of limed shale, the usual current of steam was passed through the retort during distillation, and the water of hydration of the lime in no way altered the condition of things within the retort. But the case of limed coal in a gas retort is altogether different, for there no current of steam is passing through the material. True, most of the oxygen of the coal comes off as water, but this probably occurs at a very early stage of the distillation; so that the water of hydration of the lime, coming off at a comparatively high temperature, does introduce a new condition of things within the retort. The most effective method of applying lime to the shale was found to be by washing it over with a thick milk of lime, the coating of lime being allowed to dry before the shale was put into the retorts.

As the result of these attempts to gain an increased yield of ammonia, simultaneously with a maximum yield of paraffin products, showed pretty conclusively that the end could not be attained by any simple or single process, the necessary and favourable conditions for the attainment of the one object being almost antagonistic to the others. It then, for the first time, occurred to Mr. William Young and the author to treat the residue, or "spent shale," to a supplementary operation of steaming after the oil distillation was finished. In all of the earlier trials the two operations, the distillation and steaming, were conducted in the same retort, and the temperature employed in the latter operation was little if at all higher than that suitable for oil making. It was found that, by continuing this steaming for several days, a considerable proportion of the nitrogen of the spent shale came off as ammonia. During the steaming, a small quantity of gas came with the steam, showing that some slight decomposition of steam was taking place within the retort, but the fixed carbon of the spent shale, after the operation, was only diminished to a slight extent. This experiment showed that it was possible to obtain a large quantity of the nitrogen of the spent shale, but the method of doing so was evidently quite inapplicable commercially. The cost of plant forbade the devotion of two or three days to the steaming of every retortful of shale. The ordinary operation of distillation only occupies twelve to twenty hours, so that the addition of from forty-eight to seventy-two hours for each operation would have reduced the power of the plant to one-third, and would thereby have trebled the working costs. The ammonia gain would have been more than swallowed up by these increased costs. Ultimately, we resolved to try how far the operation could be accelerated by the use of a higher temperature for the supplementary operation, and with this object a retort was fitted up, as shown in Fig. 1 (p. 317). The upper part of this retort consisted of an iron tube 12 inches in diameter, closed at its upper end by a hopper and bell, and provided with a branch or exit pipe for oil, vapours, and gases. The flange on the lower end of the iron tube was secured to the upper end of a 13-inch fire-clay tube 5 feet long, the lower end of which was jointed to a short iron flanged tube or hat piece, the flange of which, resting on a strong iron sole plate, supported the whole retort. The lower end of the hat piece dipped into water in a shallow iron tray, so as to lute the retort. This double retort, iron above and fireclay below, was built in a double oven heated by a coal fire, the fire gases being so led as first to heat the fire-clay retort to a bright red heat, the partially spent gases being afterwards led round the iron retort, heating it to a very dark red. The branch or exit pipe was connected to air condensers of ordinary form. A steam pipe was led into the lower end of the retort or hat piece.

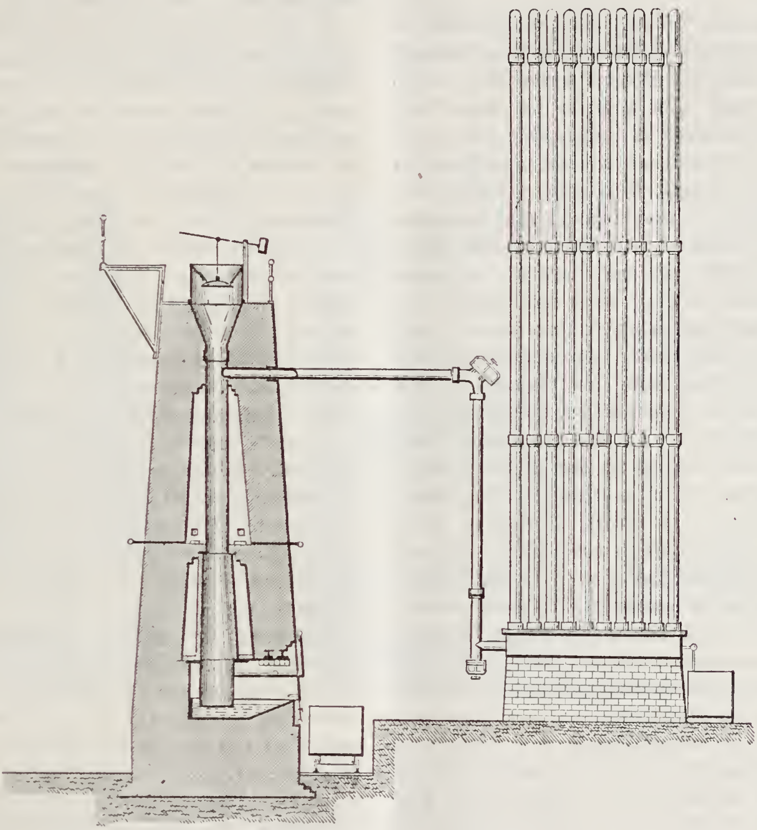
In beginning to work this retort, the heats having been raised to the proper points, the fire-clay retort is filled up to the junction of the iron retort with spent shale, on the top of which broken shale is introduced, until the iron retort is filled to the hopper, which is closed from the outer air by the bell valve. The steam entering the lower end of the retort, and passing through the red-hot material in the fire-clay portion, is highly superheated, and rapidly conveys heat to the raw shale in the upper retort, which is further heated by the flue gases passing outside. The oil vapours and steam passing off by the exit pipe are cooled and condensed, and are collected in tanks. The shale at the lower end of the iron retort receiving the first effect of the highly-heated steam, is first exhausted of its hydrocarbons, and the removal of a portion of the material from the trough, by a suitable rake, moves downwards the whole column within the retort, so that the portion of shale

exhausted of its oil products is now brought into the more highly-heated clay retort, and being subjected to the current of steam, a large part of its nitrogen is converted into ammonia, which passes away with the steam and oil vapours. As the column of material is moved downwards by the removal of portions from the trough, fresh shale is introduced by the hopper at the top, but this downward steam is so regulated that no shale containing undistilled oil comes down into the highly heated retort.

This experimental retort was intended to answer two important questions. (1.) Was it possible to win the increased yield of ammonia, by the application to the spent shale of a higher temperature, without an unreasonably heavy expenditure of time and labour? (2.) What influence would this supplementary treatment of the spent shale have upon the primary process of paraffin oil distillation which was to take place in the upper part of the apparatus?

With reference to the second question, it has already been pointed out that, at the best,

FIG. 1.



ammonia is only a secondary product from shale distillation. In 1873, the value of the paraffin oil products of a ton of shale was about 25s., while to-day it is only one-half, or 12s. The value of a maximum yield of ammonia may be taken as 3s. to 4s. per ton. From these figures, it is evident that any gain of ammonia which involved a sacrifice of paraffin products might be purchased too dearly.

The working of this experimental retort gave a most satisfactory answer to both of these questions. It was found that the double operation of extracting the paraffin oil and recovering the ammonia of the spent shale could be accomplished in from twenty to twenty-four hours. Further, instead of a lower yield of paraffin products, a decided gain in the most valuable of these products was realised. This latter result was evidently brought about from the distillation of the shale being, to so great an extent, effected by the internally applied heat brought to it by the larger volume

of highly heated steam or gas, this rapid current of gas and vapour sweeping away and preserving the newly-formed hydrocarbon vapours. As to the actual yields of ammonia realised by this retort, they reached as much as 56 lbs. of sulphate per ton of shale, and the distribution of the original nitrogen was modified as follows:—One ton of shale containing nitrogen equal to 74·8 lbs. of sulphate of ammonia, gave watery distillate containing nitrogen equal to 55·0 lbs. of sulphate of ammonia; oily distillate containing equal to 15·3 lbs. of sulphate of ammonia; spent shale containing nitrogen equal to 4·5 lbs. of sulphate of ammonia.

Although this result could be obtained at will in the experimental retort, putting through 10 cwt. of shale per day, certain features of the process, which are now to be more fully described, rendered it improbable that such perfect results could be realised in working on a really large scale. Very early in this course of experiments it was noticed that whenever the yield of ammonia from the retort rose above 25 lbs. of sulphate per ton, many of the pieces of spent shale coming from the retort were white and hard instead of soft and black, and, on breaking these pieces, it was found that this whitening entered from an eighth to half an inch into the substance, a soft black core being generally found inside the piece. This whitening was caused by the burning away, by the oxygen of a portion of the steam passing through the retort, of the 14 or 15 per cent. of fixed carbon ordinarily contained in the spent shale from simple oil distillation. It was found, by repeated analyses, that as long as the residue contained carbon, so long did it also contain nitrogen; that only when every trace of carbon was burnt away was the nitrogen completely driven out. It was also found that, if a sufficiently full current of steam was kept up within the retort, little or none of the nitrogen of the spent shale was lost as free nitrogen. An average sample of the whole residue from a day's retorting, on analysis, gave an amount of nitrogen which exactly supplemented the ammonia actually obtained. All this was favourable to the success of the process, but there remained one point, important but unfavourable. Spent shale contains about 85 per cent. of mineral ash, consisting of silicates of varying fusibility. As long as the 15 per cent. of fixed carbon is intimately mixed with these silicates, the mass is nearly infusible, but whenever any large proportion of the fixed carbon has been burned away by the oxygen of the steam, the ash softens and begins to fuse, and there is the danger that a number of pieces fusing together may plug the retort and stop the downward passage of the shale. It, unfortunately, happened that the softening point of the ash of the particular shale under consideration was at or near the temperature at which the process could be carried out with economical speed. In the practical working of this shale by the new system, it was evident that the process of burning away the carbon, and extracting the nitrogen, must be stopped short while there was still sufficient carbon mixed with the ash to keep it from fusing.

To determine more accurately the costs of the process for labour, fuel, and maintenance, a bench of sixteen retorts (as shown on Figs. 2 and 3, p. 319) was erected in July, 1881. By the working of this bench it was ascertained that, for retorts of this size and form, a yield of 30 lbs. of sulphate of ammonia per ton of shale was all that could be economically won. The general results of working these retorts were, however, so satisfactory that, in the autumn of 1881, the Oakbank Oil Company erected 288 retorts to replace an equivalent number of older retorts which had been in use previously. These retorts have continued to work satisfactorily for the past three years, last year's results having been the best yet attained. By the systems of retorting in use at Oakbank prior to 1881, the annual produce of sulphate of ammonia was 300 to 320 tons. The produce for the present year from a similar throughput of shale is 710 tons of sulphate, or a gain of 133 per cent.

Following the erection of these retorts at Oakbank, Mr. William Young carried on further experiments at Pentland Works, and succeeded in designing a form of retort which embodied the good points of the old with the most recent recent results of our joint experience. The principle on which these retorts are worked is identical with that already described, but, as will be seen from Figs. 4 and 5 (p. 320), the structure is considerably modified. Instead of cylindrical tubes, the retorts are oval, and rectangular in cross section; by this alteration the cubic content of the retorts is increased, without a corresponding increase of thickness of the mass of shale to be heated through. The quadruple hopper covering four retorts is enlarged so as to contain as much shale as the retorts themselves; the water-lute sealing the bottom of the retort is replaced by a faced mouth-piece and steel door.

One of the most important alterations is the replacement of the ordinary open furnace by a gas producer of novel construction (Fig. 5, p. 320). This gas producer is a vertical retort built of brick, closed by a door at the top, and provided with an exit pipe which connects the retort with a system of mains and condensers. At its lower end, the retort terminates in a closed fire-place and ash pit, with regulating doors or dampers. The dross or small coal is introduced by the top door, and, resting on the fire-bars, fills the retort from top to bottom. The upper part of the retort, being surrounded by flues through which fire gases are led, is kept at a full red heat. The coal at this part of the retort is distilled, and parts with gases and vapours which pass away by the exit pipe to be cooled and condensed. As the coke passes down in the retort, it is met by a current of steam which is partly decomposed, burning the carbon, and producing ammonia and "water gas," which pass off along with the other volatile products. When such coke as has escaped the action of the steam reaches the fire-bars, it is burned into carbonic oxide by a regulated admission of air. This red-hot carbonic oxide passes off by ports at the lower end of the retort, and is burned in the flues surrounding the shale retorts. The gases from the upper part of the retort, after having been deprived of their condensable constituents, are also returned into, and burned in, the setting of retorts. By this system of firing, less fuel is used than by the open

FIG. 2.

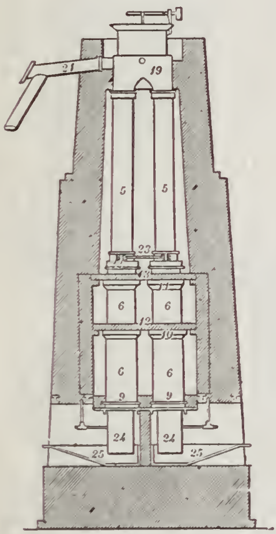
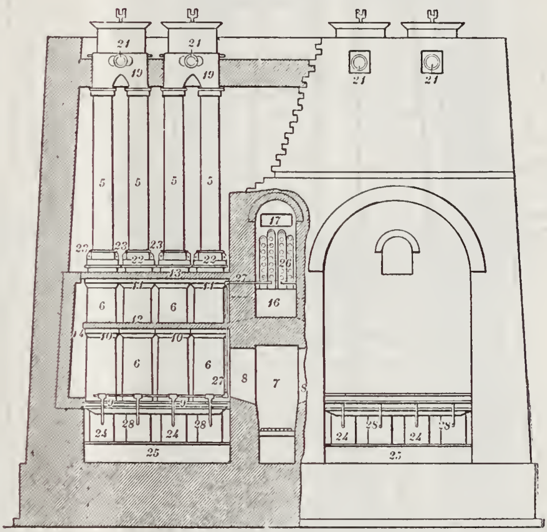


FIG. 3.



furnace, and the ammonia and tar recovered from the coal more than pay its first cost.

In the oil districts of Scotland, about 1,500,000 tons of shale are distilled per annum for the production of paraffin and oils. The following figures show the influence of the new process introduced in 1881. There are at present in course of erection, or in actual use, about 2,000 retorts capable of distilling and treating under the new system 750,000 tons of shale per annum. The admitted gain of sulphate of ammonia, by the new process, is not less than 14 lbs. per ton of shale, or 4,687 tons per annum, which, at £10 per ton, is equal to £46,870. But, in addition to this gain of ammonia, there is also an increased yield of solid paraffin valued at about £40,000 per annum. As the costs for labour, fuel, and maintenance of the new retorts do not exceed those incurred under older systems of working, the whole of the above saving of £86,000 may be credited to the new process.

By certain improvements in the process and plant, which we have been working out during the last two years, and which are now almost matured, we hope to make a further well-marked advance in economical and efficient working.

I have entered with considerable detail into the history of our researches on ammonia recovery in shale distillation, partly because the foundations of all our subsequent work were

deeply laid in that manufacture, and partly because Mr. Young's and my own close connection with the industry led us to devote the greater part of our time to its development. In the years 1880 and 1881, as the application of the process opened before us, we became more and more impressed with its probable importance in the manufacture of illuminating and heating gases, and in metallurgical operations.

Early in 1881, through the kindness of Mr. Linton, manager of the Edinburgh and Leith Gas Company, I obtained specimens of a number of well-known gas coals. These were analysed by Mr. E. H. Ronalds, the nitrogen giving the following numbers :—

Rosehall cannel		....	1·48 per cent.
Newbattle ,,		....	1·20 ,, ,,
Springwell ,,		....	1·21 ,, ,,
Niddrie ,,	(1)	......	1·69 ,, ,,
,, ,,	(2)	......	1·65 ,, ,,
Fouldshiells ,,		....	1·37 ,, ,,
Shields splint		....	1·20 ,, ,,

FIG. 4.

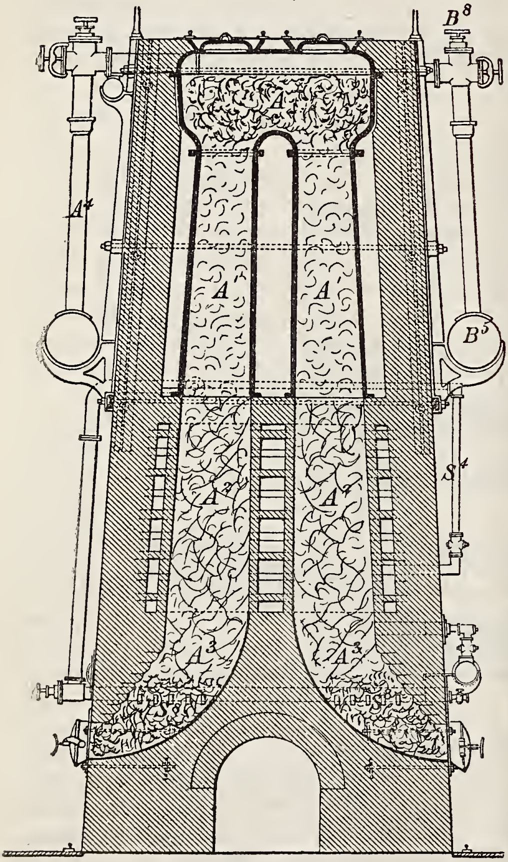
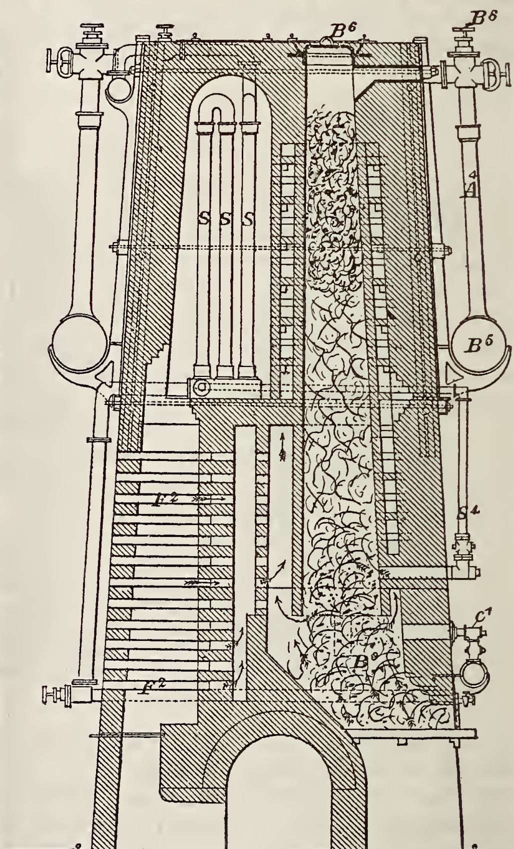


FIG. 5.



In addition to the above, various of the coals in ordinary use as fuel at Oakbank were analysed, and found to contain from 1·45 to 2·2 per cent. of nitrogen, equivalent to 147 to 211 lbs. of sulphate of ammonia per ton of coal. In December, 1881, a quantity of the Niddrie cannel was distilled and treated in the retorts illustrated on Figs. 2 and 3 (p. 319), under conditions identical with those maintained in the treatment of the Broxburn shale. As the latter ordinarily yielded about one-half of its nitrogen as ammonia under this treatment, it was expected that the Niddrie cannel, which contained nitrogen equal to 174 lbs. of sulphate of ammonia per ton, would at least yield 80 lbs. to 90 lbs. We were, therefore, much disappointed when it only yielded about 35 lbs., or one-fifth of its total nitrogen. An analysis of the coke, after leaving the retort, showed that it still contained 1·22 per cent. of nitrogen.

Taking the coke as being 60 per cent. of the original coal, then 44 per cent. of the total nitrogen of the coal had been left in it. The loss of nitrogen in the oily distillate was not determined, but must have been very high, as the weight of oil obtained was nearly twice as great as that from the Broxburn shale, and the per-centage of nitrogen contained in it was somewhat higher. Further experiments with cannel and other coals, and a careful study of all the results obtained, made it evident that the ease with which any coal or shale would part with its nitrogen under the influence of steam and a high temperature, is generally inversely proportional to the per-centage of fixed carbon left in the coke. A material that gives a coke containing 45 per cent. of fixed carbon, would take three times as long to give up its nitrogen as one containing only 15 per cent. While it is probable that the nitrogen of coke is not chemically combined with the whole of the carbon, but only with a portion of it, and that it is by the decomposition of these carbon - hydrogen - nitrogen compounds by steam that ammonia is produced, all our practical experience goes to show that it is only by burning away the whole mass of carbon, uncombined and combined, that the whole of the nitrogen can be obtained as ammonia. We have found, and Professor Foster has independently demonstrated (Proc. Inst.C.E., 1884) that steam exercises an elective action upon certain constituents of the coke, in virtue of which the coke becomes poorer and poorer in nitrogen as steaming is continued, yet, in order to carry out the operation at an economical speed, and so to obtain a largely increased yield of ammonia, nearly the whole of the carbon must be removed by oxidation. But this oxidation and removal of the fixed carbon by steam is a very slow process at any temperature at which ammonia can be kept from dissociation. The temperature at which spent shale containing only 15 per cent. of carbon can be perfectly treated in twenty-four hours, is quite inadequate for the treatment in the same time of coke containing 80 or 90 per cent. of carbon. But any attempt to accelerate the operation by the use of a much higher temperature, results in the loss of much of the nitrogen in the elementary condition, or it involves the use of an enormous excess of steam to protect the ammonia molecules, by conveying them rapidly from the retort.

That the process is quite practicable on a laboratory scale, has been sufficiently proved by its application to the analytical determination of nitrogen by Grouven. That it is also, under certain conditions, practicable on a manufacturing scale, has been definitely proved by our own experience; but, in many cases, the cost of producing and maintaining such a high temperature in a bench of retorts, and of keeping the necessary plant in repair, make the process economically impossible for the ordinary run of highly carbonaceous substances. Fortunately, the difficulty had not long presented itself before the solution was suggested. As the oxidation of the excessive quantity of carbon was the great desideratum, it occurred to us to use a proportion of air with the steam to effect this. While the oxidation of carbon by steam is a reaction in which heat is absorbed, the oxidation by free oxygen produces heat. The first attempts to carry out the process with air, on a laboratory scale, were only partially successful, as it was difficult to regulate the relative amount of external and internal heating; but on applying air injectors to two of the retorts, shown on Figs. 2 and 3 (p. 319), no such difficulty was experienced. The external temperature of the fire-clay retorts was at once reduced to a moderate red heat, and the oxidation of the carbon proceeded quietly and regularly, without interfering in any way with the ammonia production.

By March, 1882, we were in a position to formulate (patent No. 1,377, of 1882) the conditions for the successful conversion of the nitrogen of carbonaceous substances into ammonia, these conditions being, that the coke or residue should be burned in steam alone or in a mixture of steam and air, sufficient excess of steam being present to protect and carry off the ammonia as formed; the temperature, while sufficient for the combustion, to be as far as possible below the fusing point of the mineral ash. The added experience of three years has confirmed this definition as a sound one.

A few words of explanation of this definition may not be amiss. The process has to be clearly distinguished from several pre-existing operations. There are—(1.) Dry distillation. (2.) Dry distillation in a current of steam. (3.) Combustion in air. (4.) The form of combustion in air and steam practised in certain forms of gas producer. The new process is not contained in either the first or second of the above, as it essentially involves the burning away of a considerable part of the carbon of the residue in steam, which was never the case in distillation with or without steam; steam in all such cases being used to prevent or

retard decomposition, not to cause it. Neither is it found in the third, as steam is not used at all. Nor is it in the fourth, for although superficially the two operations seem alike, both involving the use of air and steam to oxidise the carbon, the employment of excess of steam, that is so much that a considerable portion of it passes through the red-hot coke undecomposed, introduces an altogether new set of reactions with products in quite new proportions. This is well shown by a comparison of the gas from a Wilson producer with the gas from our retorts.

	Wilson Gas.	Y. and B. Gas.
Carbonic acid	7·14	15·40
Hydrogen	12·15	34·53
Carbonic oxide	19·83	10·72
Marsh gas	3·91	4·02
Nitrogen	57·24	35·33
	99·97	100·00

It has been shown, in what has gone before, how comparatively easily the process could be applied to the ordinary process of shale distillation. (1.) Because of the small per-centage of carbon left in the coke or spent shale. (2.) Because a current of steam was already in use in oil-making retorts, and had only to be supplemented to a moderate extent for the new process. (3.) Because the "spent shale" had at best only a very trifling value as a fuel, and was, therefore, practically a waste material. On these accounts the extra costs involved by the process were merely nominal, so that the whole of the increased yield of ammonia was clear gain. In seeking to apply the process to new purposes many new factors are introduced. It is evident that if a gas company, turning out a good saleable coke, were to proceed to spend money in converting ten shillings' worth of coke into ten shillings' worth of sulphate of ammonia, the operation would not commend itself to business men. But if, in addition to the ten shillings' worth of ammonia a further ten shillings' worth of something else were to be obtained, the whole matter would assume a more practical aspect. In connection with this process the "something else" must be heating gas. I feel some hesitation in venturing to approach so heretical a subject as a double gas supply—for heating and lighting purposes—and have no intention of suggesting such a thing in any but a very limited sense. There is, I believe, a sense in which the realisation of a double gas supply is both possible and hopeful. In a paper read before the Mining Institute of Scotland, in September, 1883, among other suggested applications was the following:—That gas companies in the immediate vicinity of manufacturing towns might carbonise cheap coals or slack, selecting from the gas the portions of highest illuminating power to be purified and distributed in the ordinary course; the coke from the carbonising retorts to be dropped into secondary retorts below, and there gasified in excess of steam, producing a large volume of heating gas, and ammonia; this heating gas, after separation of the ammonia, to be distributed by large mains to manufacturers in the immediate vicinity of the gas work, to be used by them for firing steam boilers, pottery kilns, glass furnaces, forges, or metallurgical works of all kinds. In properly selected situations, these outlets for heating gas might be fairly profitable, as no excessive capital expenditure would be needed to lay down the distributing plant. The advantage to urban manufacturers of having a steady supply of smokeless fuel at the same cost per effective unit of heat as coal, would be very great. The advantages of of gaseous fuel in many manufactures are so well known, that it is hardly necessary to repeat them; the cleanliness and freedom from smoke, the command of temperature, the reduction of wear and tear on brick furnaces and ovens—these are a few of the advantages. In the face of such obvious advantages, we are, at first sight, at a loss to understand why gas-firing has not made more rapid advances in public favour. As far as my opportunities have enabled me to judge, it is not because any one really doubts the excellence of the fuel, when it is once produced of the proper quality, but because the ordinary run of manufacturers are not in a position to devote to the mere preparation of their fuel the amount of care and attention which are absolutely necessary, if a steady and satisfactory product is to be obtained. Hence we generally find that it is only in very large works, where the production of fuel gas is of sufficient magnitude to raise it to the dignity of a separate department, that satisfactory results are obtained. But in fully equipped gasworks we have the chief requisites for the production of fuel gas ready to hand, skilful gas engineers, and a perfectly organised staff thoroughly familiar with the manufacture and handling of large volumes of gas.

To show that the suggestion made in 1883 contained at least some element of vitality, it is worthy of note that a somewhat similar suggestion was subsequently taken up and

discussed at length in the columns of the *Journal of Gas Lighting*. This latter proposal was that fuel gas should be produced in ordinary coke generators, no other products being obtained from the coke. If such a scheme had in it the elements of success, much greater should be the prospects of a process which is capable of producing a superior heating gas, and an amount of ammonia almost, if not quite, equal in value to the coke consumed.

In two previous papers on this subject ("Mining Institute Scotland Journal," vol. v., pt. 5; "Society of Chemical Industry Journal," vol. iii., p. 216) I have entered at considerable length into the chemical and thermo-chemical aspects of the process, and in connection with the latter, have shown very fully, by means of tables, the theoretical possibilities in the production of fuel gas. It is not necessary to reproduce these figures in detail, it is sufficient to state the general conclusion, which is, that the free heat energy of the gas from the process, after deducting the heat necessarily absorbed and lost in the process itself, amounts to 70 per cent. of the theoretical heat energy of the original coal. Stating this in another way, we may say that of 100 tons of coal gasified in air and excess of steam, the heat energy of 30 tons will be used in the process, and the energy of 70 tons will be available for outside use in the form of gas. In the calculations referred to, due account was taken of the loss of heat by radiation and conduction from the retort benches. Further, no credit was taken for the recovery of heat from the gases leaving the retort, so that in a certain sense the figures are safe; but in any practical estimate it would be prudent to take the heat energy of the gas as 60 per cent. of the theoretical energy of the coal.

The problem before us, for the last three years, has been to devise a practical apparatus for the manufacture of heating gas by this process. While the theoretical conditions and results could be worked out in the laboratory, the practical solution on a working scale could only be found by the trial and modification of successive plans, at each trial getting rid of some weak point in structure or working. From the necessities of the case, such gradual elaboration of a practical apparatus must be slow, how slow those only know who have attempted to translate a process from a magnitude of grains into one of hundreds of tons. We have not yet attained perfection, and are perhaps hardly yet in sight of it, but we can confidently say that the process can be carried out in a pratical way with profitable results.

Since October, 1883, there has been in constant use, at Oakbank, a small bench of retorts which produce heating gas of the composition already referred to, and equal, we estimate, to 60 per cent. of the heat energy of the coa consumed. The ammonia produced has varied from 80 lbs. to 134 lbs. of sulphate per ton of coal, and the present average excess of steam used is about 2,500 lbs., or 250 gallons per ton. A cross section of the bench of retorts is shown on Figs. 6 and 7 (p. 324).

The retorts are fire-brick tubes of oval sections, built up of grooved and tongued bricks similar to those exhibited. Each retort is self-contained, being closed at the bottom by a faced door, and at the top by a hopper and charging door. The steam and air are blown in at the upper side of the mouth-piece, and pass up through the coke in the lower half of the retort. The gases pass off by an exit pipe built in about half way down the retort proper, and are drawn through condensers and scrubbers by an exhauster. A portion of the cooled and washed gas is led back into the setting, and by its combustion maintains the whole interior at a red heat. The gas producer in front is only used in heating up the bench at first, and after the retorts are in full work it is shut off, and the firing is done by the retort gas. When the retort is in working order, it contains in the upper part, above the exit pipe, coal in process of coking, and giving off hydrocarbon gases and vapours, which pass down through the hot coke, and are led away by the exit pipe. The lower part of the retort is full of coke which is being oxidised by the oxygen of the air and steam, the resulting gases pass upwards, and are also led away by the exit pipe. As the carbon is burned away in the lower part, the whole sinks down, making room for fresh coal to be introduced at the top. This is done either by hand or by a screw feeder. At intervals the bottom door is opened, and a portion of ashes and fine cinder is removed. In practice, we have found it of great advantage to have a proportion of unburnt cinder among the ashes, which serves to keep the mass of ash in the bottom of the retort porous and open, so that the steam and air may pass freely through. Care has to be taken that the temperature of the contents of the retort does not rise so high as to fuse the ash and run it into clinkers, as these adhere to the side, and are difficult to remove.

With the object of treating a much larger

quantity of coal in each retort, the design shown on Fig. 8 (p. 325) has been adopted. The shell of the retort is built of grooved bricks as before, but it is of circular section, and of much larger diameter than the earlier retorts. The top is closed by a shallow hopper of cast iron, with two small charging doors; through the centre of this hopper a large iron pipe is led half way down the retort. This pipe is for the exit of the gases, and passes up into a large dust-box which runs along the bench. From the dust-box the gas is conveyed by large

FIG. 7.

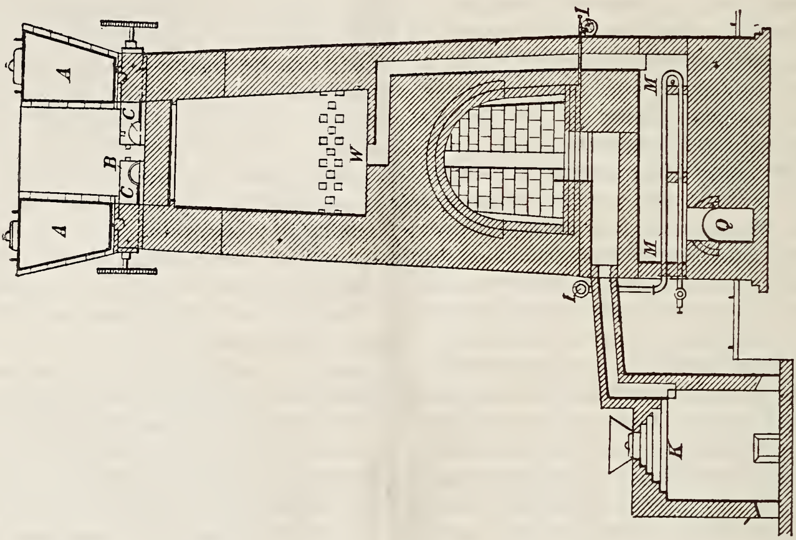
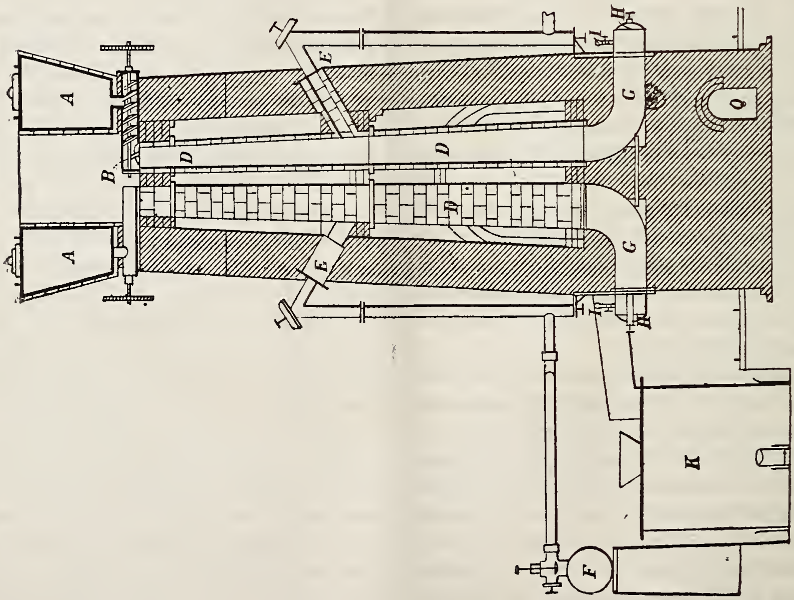


FIG. 6.

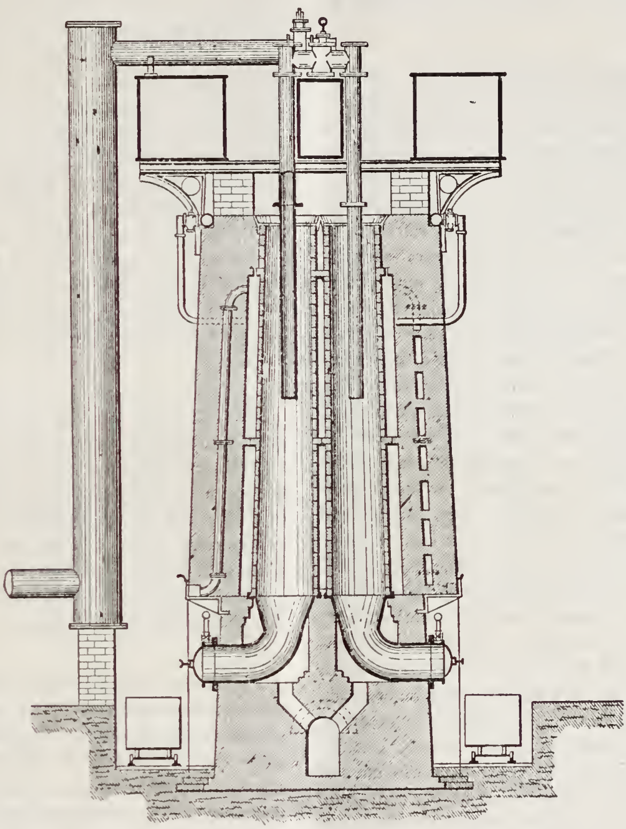


pipes to the condensers and exhauster. The bottom of the brick retorts rests on an iron snout-piece, which is provided with a door at the outside of the setting. The steam and air are blown in at the front of this snout-piece. The gas and air for heating the setting are led up by pipes between the walls of the building, and are thereby heated before they take fire. The fire gases surrounding the retorts are drawn downwards by chimney draughts, and before entering the main flues at the bottom of the setting, they give up their

heat to the iron snout-pieces through which the steam and air are entering. The working of these retorts is similar to that already described.

In both the forms of retort described, external heat is applied, and this heat, passing through the walls of the retort, takes the place of the heat absorbed by the reaction within. But it is quite possible to carry out the process of burning coke in excess of steam in a solidly built oven or cupola without any external heating. In that case, the heat necessary for the reaction is supplied in one of two ways, either by pre-heating the steam and air supply, and allowing it to take in the necessary heat, or by consuming a larger proportion of the carbon within the retort by the free oxygen of air—in other words, by using more air with the steam. The latter plan is objectionable, as the quantity of nitrogen introduced with the air, so dilutes the resulting gas as to render it almost valueless as fuel. The only difficulty

Fig. 8.



in the way of pre-heating the steam and air is in the construction of a durable form of heater. All who have had experience of steam superheating on a large scale can testify to the troublesome and costly nature of such plant. We are, however, at present working out a form of producer on the pre-heating principle which we hope will be cheap, durable, and easily worked.

I have already spoken of one application of the gas-producing process, the adoption of which will have to depend on the enterprise of individual gas companies. There is another application which we hope will be in operation before long, that is the erection of plant in colliery districts where dross or slack is plentiful and cheap, where, therefore, it will be possible to work it up for ammonia solely. Even at the present low price of sulphate of ammonium there is a considerable margin of profit on this operation, after paying costs of coal, labour, interest and depreciation.

DISCUSSION.

The CHAIRMAN said the subject of the production of ammonia from coal and shale was a very interesting one, and there had evidently been a great deal of work done upon it by Mr. Beilby and his friends. The production of ammonia had now become a very large matter, especially since its use in the ammonia soda process, and also largely for manurial purposes. A few years ago he had statistics which showed that the value of sulphate of ammonia produced from gas liquor amounted to nearly £2,000,000 sterling per annum. He did not know whether those figures were correct, but at any rate it was a very large industry, and there were many points in the paper which it would be interesting to discuss.

Professor WILLIAM FOSTER said he should, perhaps, not read the history of the earlier experiments on this matter in quite the same light as Mr. Beilby, though he quite agreed with him as to the value of some of the experiments. He had no experience himself with reference to the distillation of shale, his own observations having had reference to ordinary bituminous coal, and ordinary cannels, some of which came from Scotland, and others from North and South America; and being still engaged in these investigations, he was scarcely in a position to discuss some of the interesting points which had been brought forward. The question of the use of steam, and its history, opened up a very wide field, and he did not see how the different results arising from the use of steam at the present time could be explained, without considering more recent researches. Mr. Beilby had already expressed his opinion on some contributions of his (Professor Foster's) to the Institution of Civil Engineers last year; and he thought some of those late experiments threw a considerable light on the theory of the production of ammonia. Prior to these later methods, which were the subject of letters patent, steam was used with the view of preventing the breaking up of ammonia in the retort. Speaking from memory, the amount of ammonia lost in the ordinary distillation of coal was about 25 per cent. from one class of coal, another 35 per cent., another 21 per cent., and another 30 per cent. Those numbers represented the per-centages of the nitrogen of coal, which by the most advanced process were lost to the gas producer. When steam was introduced into the retort, in the way described, it was probable that a portion of this was saved. Of course, after the volatile hydrocarbons had flown, the steam began to act on the nitrogen of the coke. Still, this was a debateable matter, and on it the whole thing turned, for if these recent experiments had any value, it could be shown that this action of steam could only take place by preventing the breaking up of that portion of the ammonia in the retort which came off in ordinary distillation, and was never recoverable as ammonia. There was such a margin of waste in the ordinary mode of distillation, that the steam might very well increase the yield of ammonia without touching the great reserve of nitrogen, which the author and his able colleague Mr. Young, and others who had been working on similar lines, had been trying to get at. In the latter portion of the paper reference was made to the erection of works for the recovery of bye-products from true coal; there were works already in existence not far from Sheffield for that purpose; but he feared that some of the statements made were scarcely applicable at the present moment. Sulphate was now down in price, say £12 free on board at Hull, whereas a few weeks ago it was up to £15 or £16. He did not know whether it had yet reached its lowest level, but putting the value at £10 a ton, he thought the author allowed very little for the sulphuric acid, labour, and so on, required to work it into sulphate. He feared ammonia had not yet seen its lowest price, and therefore it would be unwise to lay down any hard and fast line as to the money value which this ammonia was likely to bring. The author had done a great deal in showing the practical possibilities of shale distillation, which might be taken as illustrating what might happen in the case of small coal if subjected to similar treatment, but he did not think the operations had been carried on on a sufficiently large scale to influence very considerably the output of ammonium salts.

Mr. NEWLAND said it looked as if there were a great future for this particular mode of treating shale and refuse coal products. Many years ago, in connection with the late Professor Wray, he endeavoured to utilise the ammonia from refuse coal, but their experiments were conducted in a more simple manner with the use of hydrated lime, and they did not attempt to prosecute the matter in the way which Mr. Beilby had so ably done.

Professor FOSTER asked if the author could state the increase in the yield of ammonia by methods similar to the one he had brought forward, and what were the possibilities of increased ammonia production in comparison with what they were a few years ago. In Gartsherrie and other places, large quantities of ammonia were being produced at the present time, and it would be interesting to know how much ammonium sulphate was being put on the market from these new sources.

The CHAIRMAN asked Mr. Beilby whether a much larger amount of volatile hydrocarbons and gas were produced by this process.

Mr. BEILBY said he was very well acquainted with and fully appreciated the excellent work which Professor Foster had done in the way of clearing up many of the knotty points in connection with the

nitrogen of minerals, and its behaviour under dry distillation and otherwise. He had asked further particulars as to what actual results had been obtained from coal. He had devoted the greater part of the paper almost necessarily to the discussion of the subject of shale, because that had been really the principal subject with which he had been engaged, but he did not desire to dwarf in any way the importance of the process as applied to coal. He considered the treatment of coal was far more important, and had far more possibilities in it than shale ever would have. He had given the actual commercial figures of the saving being effected in this one small industry, the Scottish oil trade, showing the saving of ammonia equal to £46,000 sterling per annum. If the whole of the shale were treated in Scotland by this process, it would not much more than double that amount, and it was, therefore, evident that the possibilities of extension in that direction were very limited, and many years ago, therefore, Mr. Young and himself turned their attention very seriously to the utilisation of the nitrogen in coal, feeling quite certain that in it there was a much greater hope of a large success. He had pointed out in the paper a number of practical difficulties encountered in carrying out the processes, but still it had been brought down to this point, that for a year and a-half they had been treating coal on a manufacturing scale—a small one certainly, 4 to 5 tons a day—for the production of heating gas and ammonia, and the results had been remarkably steady. It was not a laboratory experiment, and was not under the direction of chemists, but had been conducted by ordinary Irish labourers working retorts, and the results, therefore, were thoroughly practical. As he had pointed out, the real difficulty was that it took such a long time to burn away the carbon in steam, that air had to be introduced to expedite the process. But since that had been done, the whole process had been marvellously simplified, and could be carried on on a large scale. Mr. Foster had almost suggested that it was not possible to obtain the whole of the ammonia present in a material such as coal or shale by simple treatment, with excess of steam of sufficient temperature, but it was possible, as had been proved time after time, to do so. The analytical method at least proved that the whole nitrogen could, by proper care, be obtained, and it had been done time after time, in his own laboratory, for, after carefully analysing the residue and ammoniacal liquors, and striking a balance, it really came out with marvellous accuracy, showing that, practically, the whole of the nitrogen was accounted for. In the case of a shale retort simultaneously producing paraffin oil, which necessarily contained about 20 per cent. of the total nitrogen, you could not obtain that portion as ammonia, but in the case of coal, where the hydrocarbon vapours were almost entirely decomposed by steam, in their passage through the red-hot coke, the theoretical possible quantity of nitrogen could, with care, be obtained. He had abstained, purposely, from entering fully into the chemistry of the question of the decomposition of steam, and the state in which the nitrogen was found in the coal, because he had already expressed his views in a paper read before the Society of Chemical Industry last spring. Mr. Foster had further asked for information as to the actual quantity of ammonia produced from such sources as blast furnaces, gas producers, and generally, such improved methods as had come into use since 1880 and 1881. According to a rough estimate recently made, the total output of ammonia from blast furnaces and coke ovens in the west of Scotland was from 3,000 to 3,500 tons per annum. He had never heard of any really successful process on a large scale for obtaining it from gas producers. There had been much experimenting, but he knew no one actually producing sulphate of ammonia by the ton except themselves. The increased quantity of sulphate of ammonia produced in the Scottish oil trade, was about 4,000 tons a year, which was a comparatively small quantity as yet; the total quantity produced in the United Kingdom being about 80,000 to 90,000 tons. With reference to the use of lime with coal, they had all been interested in the coal liming process so much advocated lately, but it was quite evident to those who studied the subject that hydrated lime could never take the place of soda lime in producing ammonia in a gas retort. Apart from the state of division in which the two substances existed, the hydrated lime gave off water at much too low temperature to do the work required. The hydrogen ought to be liberated at a temperature at which water decomposed, and carbon oxidised. The Chairman had asked as to the loss of hydrocarbons by the excessive quantity of gas, and there he had put his finger on a very important point. In the case of shale distillation, before this new process was introduced the quantity of gas obtained per ton was something like 1,400 cubic feet. At present, working with steam alone, they obtained 8,000 to 9,000 cubic feet, therefore, they found it was necessary to exercise a great deal more care, and to provide a great deal more plant to recover the additional quantity of volatile hydrocarbons thus carried away. In the coal retorts, in which they produced gas to the extent of about 150,000 feet per ton, they had only by scrubbing been able to obtain benzol, or gas naphtha, equal to about half a gallon per ton; whether it was through a deficiency of the scrubbing arrangement, or to a complete decomposition of the benzol in the retorts, he did not know, but it would be quite hopeless to scrub off the volatile hydrocarbons from such an enormous quantity of gas; it cost quite enough to put up the plant which was required for the purpose of condensing the steam out of it.

The CHAIRMAN then proposed a vote of thanks to Mr. Beilby, which was carried unanimously, and the meeting adjourned.

ELEVENTH ORDINARY MEETING.

Wednesday, February 18, 1885; LORD ALFRED S. CHURCHILL, Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Craik, George Lillie, 29, Bedford-street, Covent-garden, W.C.
Johnson, Charles (Messrs. Llewellyn and James), Bristol.
McCabe, H. Bernard, 45, Friday-street, E.C., and Kings Langley, Herts.
Morris, Frank, Gasworks, Brentford.
Muir, James, Staunton Harold, Branksome-park, Bournemouth.
Obicini, George W., 109, Adelaide-road, N.W.
Platt, James, Rookwood, Hampstead, N.W.
Reynolds, Donald Fraser, 42, Charterhouse-square, E.C.
Symons, Simon, Belfort-house, Farquhar-road, Upper Norwood, S.E.
Williams, Thomas Henry, 5, Gloucester-road, South Kensington, S.W.

The following candidates were balloted for and duly elected members of the Society:—

Bhownaggree, Mancherjee Merwanjee, 107, Warwick-road, W.
Hughes, Prof. D. E., F.R.S., 108, Great Portland-street, W.
Julian, Robert Hill, 1, Roseneath-villas, Military-road, Cork.
Kraftmuir, Edward A. H., 11 A, Albany, Piccadlliy, W.
Marks, Thomas T., Stratford-villa, Llandudno.
Paxman, James, Hill-house, Colchester.
Takhtsingjee. The Maharajah, K.C.S.I., Bhavnagar.
Thomson, James Hall, Newstead, Perry-vale, Forest-hill, S.E.

The paper read was—

MALT-MAKING.

By H. STOPES.

The fact that the important industry of malt-making has hitherto attracted so little attention, or received such scant notice from the numerous members of the Society of Arts, warrants the production of a paper concerning it at this time. Were it still continuing in the iron fetters of the law that so long held it in a state of complete bondage, any paper would be capable of effecting but little reformation. As the making of malt is now as completely free as any other useful and lawful process of manufacture, it may be decidedly beneficial to all engaged in it to have it introduced and discussed by the members of this Society.

Few industries can claim an earlier origin than malting. Probably no other in Britain has made so little progress, or been affected so slightly by the revolutions that the past and present generations have practically made in every other department of human employment. This is the more remarkable, as malting is distinctly an industry in which science can aid empirical methods of development.

The fettering influence of the Malt Tax is the alleged cause of the want of development manifested by every department of the trade, but this cause is inadequate to account for such singular lack of improvement as has been witnessed. There is but a slight difference in making malt now from the practice of a hundred or even a thousand years ago. The vast majority of maltsters for ages have gone on making malt, generation succeeding generation, apparently content to perform the whole work by manual labour, aided by two, or at the outside three, tools of the rudest and simplest character, and almost entirely oblivious of the most commonplace of the scientific considerations that should guide them in their work. The chief implement they used was probably the first that civilised man made, or, perhaps more correctly speaking, that first helped to civilise man, viz., a shovel or spade of wood. Although naturally the buildings in which malt has been made have gradually improved in construction and gained in size, some of the newest and largest malthouses are still constructed in entire and utter ignorance of the primary requirements of the barley or other grain which is made into malt within them.

To brewers and distillers, malt is a material of fundamental importance. Several generations of farmers fancied it was also of great importance to agriculture in the dual sense of ruling considerably the production of corn, and aiding the stock-keeper in his processes of feeding. The great bulk of mankind should take an interest in the curious changes effected in many species of the *Graminaceæ* by germination, for, altogether apart from the production of alcohol, they gain properties capable of exerting material influence upon the well-being and comfort of varied members of the human family.

Malt is any corn, grain, or seed which can be artificially germinated within certain limits, so that it admits particular influences affecting the constituents of such corn or seeds to be developed at the will of the maltster. Other

grain than barley has for ages been made into malt, and other processes also than germination have been successfully adopted to make barley, maize, or rice, &c., into malt.

It is difficult to define the nature or limit of the influences of germination or gelatinisation. In the first place, our knowledge is yet capable of much extension, and the subject itself is very intricate. This accounts for the small impress left by the few great minds that have already approached the question in detail, or as a whole. Many generations of men have doubtless tried to explain why and how malt differs from the corn from which it was made, but to this moment no satisfactory or explicit solution has been offered.

Of the antiquity of malt-making little need be said, for such inquiry is of little practical value. Still, numerous historic references invest the subject with a certain interest. The power of many seeds to produce malt was discovered at a very early stage of man's development. No positive evidence of the existence of malt has yet been furnished from the *débris* of the Swiss Lake dwellings, but some day it probably will be. Many classical writers of antiquity allude frequently to the preparation, use, and effects of certain fermented liquors made from barley, wheat, &c., by the ancient races of Europe, Asia, and Africa. Herodotus attributes the invention of beer to Isis, wife of Rameses II. Pliny, Aristotle, and Strabo speak of it, and Diodorus affirms that some beer was so palatable as to be scarcely inferior to wine. As Pliny speaks of liquor made from steeped corn, and Wilkinson found traces of malt at Thebes, we may fairly conclude that malt was generally used, and consequently that it has a high antiquity. All the nations of Europe in earlier ages made beer, and the consumption of malt in Europe alone has been truly immense for upwards of 2,000 years. The process of manufacture, described by Geopinus, indicates that it was to all intents and purposes made by the ancient Britons in the same manner as in many primitive maltings in Europe and our own country, which are at work at this moment.

Malt occasioned legislation at a very early date, and appears to have confounded farmers and political economists five centuries ago as completely as it has those of the present generation. From the ninth year of Edward II. (1315) until the forty-third of Victoria (1880), which was the last time a law was passed materially affecting malting as an industry, legislation has been effected almost every year.

It is of more importance to define the nature of the changes induced in corn by malting than to find its inventor; but the origin of malt-making is shrouded in less obscurity than these changes. The secret has not yet been revealed to our weak powers of observation. Many analyses have been made by numerous chemists, and of course such differences as exist between the finished malt and the corn it was made from are duly tabulated; but, eminently satisfactory and useful as these analyses are, they do not furnish all the information needed by the distiller, brewer, farmer, and physician.

The industry is an important one. For very nearly two centuries it furnished a large and constant revenue to the State, in the form of a direct tax upon the product or finished manufacture, producing every year for more than half a century upwards of 5½ millions sterling.

In 1879-80, the last year of the collection of the Malt Tax, the amount paid was 6¾ millions sterling, whilst during the seven preceding years it amounted to—

1879	£7,739,507
1878	7,721,548
1877	8,040,378
1876	7,654,671
1875	7,746,740
1874	7,753,617
1873	7,544,175
	£51,200,636

£51,200,636 ÷ 7 = £7,314,375—annual average.

The quantities of malt made during the last three years of collection of the malt duties were—

	Bushels used by brewers.	Bushels used by distillers.	Duty free for export.
1878-9 ..	58,036,155	7,189,275	507,805
1877-8 ..	58,137,196	7,466,610	536,384
1876-7 ..	60,526,682	7,049,466	511,692

176,700,033 + 21,705,351 + 1,555,881 = 199,961,265 ÷ 3 = 66,653,421 bushels ÷ 8 = 8,331,677 quarters—mean average for the last three years in which correct quantities were tabulated.

These figures, however, do not include the large quantities made for, and used secretly in, illicit distillation. Since the repeal of the Malt Tax the quantity of spirit so produced has doubtless increased, for, as pointed out by me in a paper entitled "Some Results of the Repeal of the Malt Tax," and read at the Swansea meeting of the British Association, 1880, the power to make malt entirely free from supervision of the Excise must tend to such a result. Herein we find a cause for the

recent diminution of the Spirit Duty, which I suspect is greater than Excise officers admit. As 600 to 700 illicit stills are found and destroyed per annum, it is fair to assume the number undiscovered is considerable, and the quantity of spirit made to be large.

Although Great Britain makes the largest amount of malt of any separate state in the world, several other countries make very large quantities. In the absence of returns, it is not possible to make comparisons, but from the quantities of beer brewed I have calculated that the quantity of malt consumed by brewers in Europe and America is considerably over 170,000,000 bushels per annum.

	Bushels.
Great Britain consumes over............ (exclusive of private brewing).	50,000,000
Germany and Austria consume over	60,000,000
Belgium and France ,, ,, ...	20,000,000
Russia, Holland, Denmark, Sweden, Norway, Switzerland, Italy, and Greece, consume over	13,000,000
America consumes over	27,000,000
	170,000,000

In addition to this there is a very large quantity used for making spirits, bread, cattle-food, and many other purposes which cannot be ascertained with any approximation even to accuracy, but in Britain alone the distillers use upwards of 7,000,000 bushels per year.

At a low computation the capital permanently invested in malting in Britain may be estimated as follows:—

Value of buildings	£15,000,000
Value of appliances and tools	2,000,000
A total of	£17,000,000

As the raw material can be purchased once each season only, the value of the corn used in ordinary seasons about equals the value of the malthouse in which it is made, so we may assume the working capital involved in the business in Britain to be nearly another £15,000,000.

The number of men needed rightly to make eight million quarters of malt per year should not be less than 14,000.

The actual number of maltsters enumerated in the last census returns is 9,531.

The total number of malthouses and licenses show very remarkable fluctuations. Thus, in 1785, when the maltster's license was first collected, there were in—

	England.	Scotland.	Ireland.
1785	12,314	1,567	*
1800	8,752	311	—

a falling off in fifteen years of 28 per cent. in England, and 80 per cent. in Scotland.

With slight annual fluctuations, these figures stood nearly stationary for twenty-five years, until 1825, when there were—

	England.	Scotland.	Ireland.
1825	9,595	1,758	339
1826	10,468	3,943	395

These high numbers kept up for twelve years, when a steady decline set in until 1880, the last date of collection of licenses, when the numbers had dwindled down to—England, 707; Scotland, 150; Ireland, 49; a total of 906 for the United Kingdom.

This number will probably still further diminish, should brewing continue to become a closer monopoly; otherwise every brewer will eventually become a maltster also.

The days when nearly every parish or district had its small malthouse are passed, much to the benefit of the industry as a whole, and so long as the duty continued it was no loss to agriculture; but the concentration of the industry in comparatively few great centres will eventually occasion greater direct loss to the English farmer than it has already accomplished.

Two centuries ago, when the population of this country was only 5,000,000, the quantity of malt made was six bushels per head, or 30,000,000 bushels. One century later, when the population was nearly 10,000,000, only 28,000,000 bushels were made, or 2·8 bushels per head. In 1880, with a population of nearly 35,000,000, the malt made was but 65,000,000, or less than two bushels (1·85) per head. The calculations made frequently as to the diminution of beer-drinking indicated by these figures are so far inaccurate, because it is usually forgotten, that we now produce from the same quantity of malt twice as much beer as they did two centuries ago. At the time when malt liquor formed the staple and almost exclusive drink of the Teutonic races, the consumption of malt was very large. Beer was made stronger then than now, and also very inferior in every other respect. During the periods now compared, the consumption of

* No account kept of license charged in Ireland till 1818.

tea, coffee, wines, spirits, and mineral waters, has enormously increased.

Malt-making will eventually gain largely by the repeal of the Malt Tax, but, as I pointed out, both before the repeal and after, at the meeting of the British Association, at York, in 1881, farmers must lose largely. The arguments then adduced by me have never been refuted, and experience shows their correctness. English barley can never again attain to such prices as it might had the tax continued, and the benefits to farmers of securing malt for feeding purposes and brewing beer are so small, that they do not—and never can—compensate for a reduction in the price of barley of one shilling per quarter. The tax created a monopoly in English barley, which practically kept the price at the fictitious level of at least four shillings per quarter above its intrinsic value. Farmers would not believe it, but it is proved by stern, incontrovertible fact. It is also not a little curious how suddenly the value of malt as food for cattle has depreciated. A little malt, as a condiment, is in many cases useful, but for general feeding purposes it is wasteful, unnecessary, and even, at times, harmful. Healthy animals, that have their teeth, do not require diastatic action to assist them to assimilate their food, and malt, however made, consumes labour. Certain soluble constituents of barley are also inevitably lost. The quantities of malt made duty free for feeding purposes were sufficient proof of this years ago, apart from the able experiments of Sir John Lawes. The power to make malt for feeding was granted in 1864, and we find that in

1865	60,247	bushels	were made.
1866	29,094	,,	,,
1867	5,170	,,	,,
1868	713	,,	,,
1869	316	,,	,,

Since 1870, none has been made, and the sudden falling away sufficiently explains the true feeding value of malt in quantity.

There are many kinds of malt produced, and several methods of manufacture in general use. Barley is most commonly malted, but wheat, rye, rice, and maize are at times, and in some countries, very largely employed. The malts generally recognised in commerce are known as white, amber, crystal, blown, brown, or porter, black or patent, and gelatinised malt. In addition to these somewhat ambiguous but still fairly general terms, there are numerous local or other less known designations. Malt is used in the production of very many and varied types of alcoholic beverages, including whisky and other spirits, stout, porter, ale, beer, and other so-called malt-liquors, together with vinegar. It is also used for horse, cattle, and sheep feeding, and recently as human food in numerous extracts, bread, &c. It is further of use medicinally.

These facts sufficiently demonstrate the great extent and importance of malt-making, and render self-evident the statement, that in the limits of a paper intended for discussion by this Society, it is not possible to deal fully with any branch, nor to do more than allude to several of the less important.

Confining ourselves chiefly to our own country, and to the more important phases of the subject, we may consider it under the following heads :—

I.—The materials used in malting.
II.—The processes of manufacture.
III.—The crude and finished products.

I.—The Materials Used.

The contention has recently been raised in papers of high standing, that malt can be only made from barley, and solely by the process of germination. These contentions are obviously absurd. For many ages malt has been made in this country from wheat and oats, whilst the preparation of *chica* in Peru, *bousa* in Nubia, and *koji* in Japan, furnish illustrations of kinds of malting, independent of germination, which should not be overlooked in discussing this subject. Another mode of preparation of malt, altogether dissimilar from the common process of partial growth, is furnished in the gelatinisation of corn.

Still the broad fact remains, that barley is much more extensively used for malting than any other fruit or seed, and this doubtless arises from the nature of the skin, and its component parts. Barley husk furnishes better protection to the developing acrospire than the skin of any other fruit. Also, as the main end of malt is to produce special alcoholic beverages by ordinary methods of fermentation, or, to a minor degree, by distillation, it is found in practice that from the particular proportions of nitrogenous and starchy matter naturally found in barley, it is, in the first instance, better able to furnish the several sugars in the best proportion for conversion ; secondly, the right food or pabulum to the yeast cells employed in splitting up the

sugars of wort into alcohol; and, thirdly, to combine therewith the best flavouring, colouring, and other characteristics to the numerous products of the brewer, distiller, and various other traders and manufacturers.

Nearly one hundred varieties of barley are malted, and as certain characteristics are approved, or others condemned, by maltsters, the improved cultivation of barley has been much fostered by the industry of malting. Now that malt can be made entirely upon its merits as malt, totally independent of any fiscal or legal restrictions and bounties, the chief characteristics of good barley are curiously altered, and such alteration must greatly influence eventually the cultivation of barley in Britain.

It is now found that the characteristics of good malting barley are best classed in two groups, of four essentials, and six non-essentials. Of these, placing them in order of merit, the four essentials are :—

Vitality.
Condition.
Maturity.
Odour.

The six non-essentials are :—

Size.
Weight.
Uniformity.
Colour.
Appearance of skin.
Age.

The practical acceptance of this classification of the characteristics of barley most suited to produce beer in the best manner, virtually means a still further reduction of value of all barley grown in Britain. Size and weight have lost all the fictitious value conferred upon them by the Malt Tax.

The other materials malted are wheat, oats, rice, rye, maize, peas, and beans. Of these, wheat and oats alone are malted commercially, by growth in this country, and rice by gelatinisation in Britain, or by mycelium growth in Japan.

Next to the corn used, the most important material to a maltster is water. Commonly it is supposed that any water will do for malting, but this is a sad and wasteful error. Hard and moderately saline water is almost always better, under any circumstances, than that which is soft and extractive. Another material, much overlooked in practical working, is the coal or coke consumed in drying. The hardest and best anthracite coal, or oven-coke, should be alone used. It is not unusual to find common gas coke, wood, and other unsuitable fuel burned. The practice of making blown or brown malt by use of faggot or billet wood is wasteful and delusive, for it is an expensive way of securing colour and flavour which can be better attained at much less cost.

Apart from a very small quantity of bisulphite of lime, or other similar antiseptic, to prevent mould or developments of other low organisms in the damp green malt, no other materials are commonly used by maltsters than those enumerated.

II.—The Processes of Manufacture.

The modes of making malt are few and simple. What is now commonly practised in Britain is almost unaltered from that of our forefathers; indeed, maltings are working at this hour, which employ no other tools, and do not make any better malt, than described by William of Malmesbury, as made by the monks of many Midland monasteries in the time of Henry II.

Malt, to be properly made, has to be steeped or saturated with water, grown, and dried in houses and utensils specially constructed for the purpose. Such houses are very rarely built of a size smaller than what is technically known as a fifteen-quarters steep, *i.e.*, every three and a-half or four days they wet or steep 15 qrs. of grain, which gives a capacity of 120 qrs. of malt made per month. As houses of this character usually work for seven or eight months annually, their total capacity is considerably under 1,000 qrs. per annum. In many cases houses of this size are worked entirely by one man, who, during the four summer months, commonly follows some other craft, such as thatching or bricklaying. It is rather hard work for one man to attend to 15 qrs. in a small malting, but in larger houses it is customary to expect each man to work from 14 to 18 qrs. When malting commences in October, the maltster has to receive the barley, screen, sort, and pass it into the cistern steep, then couch and floor it, raise to the kiln and dry it, tread, screen, store, and again screen it, and measure or weigh into sacks for use. All this, involving constant care, skill, and attention, is performed for the wage of from 14s. to 21s. per week, or from £30 to £40 per annum. On an average, the value of the malt made would be about £2,000. The difference in the value of such malt, if well and intelligently made, or carelessly attended

to and spoiled, would be from £200 to £500, or more.

A malthouse has to be of strong solid construction, and consist of two or more floors and a kiln. The shape and size are always ruled by the position of the house, and the nature of the site; but they should follow the relative proportions that experience has taught to be the best for the purpose of making malt, that is to say, the length of the growing floor should always exceed the breadth by at least two to one. The growing floor is often below the ground line of the adjacent soil, to ensure uniformity of temperature, and the cisterns are of varied forms and position. They should be so placed that control of the temperature of the steep liquor can be secured, as temperature in cistern and couch has great influence in starting growth. In but few malthouses in Britain, however, is any attention paid to this most important point. Corn should be screened into the cistern already filled with water in order to allow the thin corn and refuse to float away. The water is best if run in from below and allowed to overflow at top, prior to a change of steep liquor, or at any time during the continuance of steeping, which operation lasts for from fifty to eighty hours. The cisterns should also be so made that the disagreeable labour of emptying by shovels is obviated. Grain will always run down to the couch frame if the cisterns are rightly designed and placed. Their capacity should also invariably be ample to steep the utmost quantity of corn the floor can possibly grow in the coldest weather.

The growing floors are made of many materials; probably tiles are most esteemed, but erroneously so. The idea has struck several maltsters of having a double growing floor, the upper one of some porous material perforated, so that ready circulation of air and discharge of the carbonic acid produced by growth may be secured. This plan is being worked in several places, and it raises a question of great interest and importance, but a porous floor for malt is a dangerous and undesirable thing. To grow malt at all in this way is doing in a perfunctory manner that which is worth doing well.

The size of the growing floor is the gauge of the capacity of the malthouse, and every measurement of all other parts should be calculated upon such size. A 15 qr. house, such as I have described, should ever have a superficial area of combined couch and floor room of 2,600 ft. if in the south of England, or 2,400 ft. if in the north of England or Scotland, unless any exceptional condition of altitude or position affect the mean annual temperature of the floor. It cannot be too often impressed upon all connected with malting in any way, that the two prime factors in making good malt are heat and air supply, and the manner in which they are communicated to, or absorbed from, the grain.

Throughout the whole of the early processes through which malt passes, it is important to secure a good supply of cool moist air to the corn, until the growth is stopped, which commonly occurs eight or ten days after steeping. In small and ordinary maltings, this air can only be given or controlled by regulation of windows, doors, &c., and the same means are employed to regulate temperature. In fact, these agencies, coupled with the use of the shovel in turning, and the particular construction or position of the house, are the only ones employed, in the vast majority of maltings of every size, to regulate or control the two chief conditions of malt-making. A new invention of M. Saladin, of Nancy, is of great utility in regulating air supplies to large maltings and for many other purposes. It is called an "échangeur," and is an ingenious utilisation of the well known rapidity of evaporation of any liquid when spread out in very thin layers over large surfaces and exposed to air currents. It consists of a series of cylinders of decreasing diameter placed one within another, consisting of finely perforated sheet-iron. They are placed in a shallow trough of cold water sufficiently deep to immerse the smallest cylinder. When rotated at slow speed all surfaces are kept wet and a volume of air is either drawn or driven through. This in its passage first comes into contact with the cylinders, and if hot and dry becomes rapidly moist and cold, for the constant evaporation has a powerful refrigerating influence. By increasing the area of evaporation surface, and causing the water or glycerine to circulate in the trough, any column of air can be wetted to the saturation limit corresponding to its temperature, and reduced to the actual temperature of the water used. This apparatus accordingly gives the maltster complete control of the humidity and heat, as well as volume, of the air driven through germinating grain.

Growing barley is kept moving upon floors by partial or complete turning every few hours; it is also usual to sprinkle it with water, should it be required, during this time. The great art of a maltster is manifested in cultivating the radicles and acrospire in the best manner

during this stage of the process. The corn, when sufficiently grown, is taken to the kiln, or drying-house, a building in which the conditions of air and heat are exactly opposite to those already described. Heated dry air is made to dissipate and remove as much of the moisture as can practicably be abstracted from malt, to utterly stop the growth, and, at the same time, to impart characteristic flavours, and influences which affect the flavour and colour of the beer, spirit, or other product of the malt. The kiln should always be a lofty and roomy structure of brick, with a high-pitched roof, surmounted with a cowl. The area of the drying-floor should never exceed one-fourth, or be less than one-sixth, of the growing-floors, nor should the combined air inlets and discharges ever bear a ratio to each other exceeding that of 4 to 5. Inattention to, or ignorance of, this simple fact on the part of kiln builders has caused an enormous waste of fuel, and damaged immense quantities of malt. The furnaces of kilns vary greatly, and upon the form, the area of grate surface depends. The drying-floors should be two in number, placed a suitable distance apart. The lower one should have its distance from the fire regulated by the construction of the house and the character of the malt desired. In altering old kilns, I have had opportunities of trying all heights ranging from 5 ft. to 29 ft. In new kilns the right limits are from 12 ft. to 18 ft., somewhat ruled by utilisation of the kiln for malt storage.

The first kiln in this country successfully worked with double floors was altered by me four years ago at Brighton, but very many are now at work in all parts. Instead of green or wet malt being raised to uncertain temperatures upon one floor, where it has frequently to be turned, it is put for from forty to sixty hours upon the top floor. It is then dropped upon the bottom floor, a further charge of green corn following at once upon the top. The benefit is mutual. The malt below is maintained at an uniform heat, for it is virtually plunged in an air bath; free radiation is prevented, for the top surface of the malt is necessarily nearly as warm as that next the wire, which, as a consequence, may be kept lower than would be necessary if free radiation from the surface were allowed. The top floor, by the intervention of the layer of malt between it and the fire, is prevented from coming into direct contact with heat of a dangerous and damaging degree, for excessive heat, when corn is still green, not only gives colour, but causes other grave evils. The same heat which is used to dry one floor, and in an ordinary kiln passes at once into the air and is wasted, is the best form of heat to remove the moisture from the second layer of malt at a low temperature. It is of vital importance to retain this green malt at a low temperature, as long as any degree of moisture exceeding, say, 15 per cent. is retained by the corn, for there is very little doubt that the influences of heat and moisture at this stage of malting are amongst the most important of any the brewer can exert in brewing. By them the quality of beer is very greatly affected. The degree of heat upon kiln and the duration of particular temperatures rule the per-centage of dextrin produced by the malt, the colour of the resulting wort and beer, and, in a most marked way, its stability. A final distinct advantage of double floors is the abolition of turning the drying grain, which, in ordinary kilns, is disagreeable and wasteful work. Not only is labour saved, but the very serious injury is averted of placing dry malt above that which is damp and of allowing it to become repeatedly dry and wet by the absorption of the steam given off by the damper portion. The economic advantages of this form of kiln are manifestly considerable.

All maltings worked in the common manner, together with those worked upon the Stopes' system, labour under the disadvantage of inability to control rightly the temperature and conditions of air supply, or germinating grain. A comparatively new form of malting is known as the pneumatic system, which may be freely described as the absolute control of the conditions of all air supplied to growing grain, and its consequent modifications of growth. This has been for several years known in Britain, and is largely adopted abroad. Owing to our singular insular prejudices, only four of these houses are as yet at work in Great Britain, notwithstanding that the users are well pleased with them; and they possess numerous advantages, with only one disadvantage (if it may be called one in this mechanical age) viz., the consumption of greater power, and a consequent reduction in the number of workmen to one-third of that otherwise necessary. The area occupied by the buildings does not equal one-third of ordinary houses, whilst the actual growing floor-space is only one-seventh. The use of plant and premises is continuous, the process of malting being equally well conducted in the hottest weather. The great advantage of this

is, that brewers secure entire uniformity in the age of malt, while, by the old system, the stocks of finished malt necessarily fluctuate largely. All growing corn is subjected to the same conditions of exposure, air, and temperature. The volume of air supplied to the germinating corn is entirely under control, as are also its heat and humidity, and it is further freed, inexpensively, from all impurities, disease-germs, &c. The infrequency of turning the germinating grain benefits the growth of the roots, and the development of the plumula, besides saving much labour. No grains are crushed or damaged by the feet of the workmen. The capital employed can be diminished by the reduced cost of installation, the reduced stocks of malt in hand, and saving of wages. The quality of the malt made is much improved. The per-centage of acidity is reduced, the stability of the beer increased, and a greater per-centage of extractive matter of the barley is obtainable by the brewer, or other user of the malt. These advantages must eventually be recognised, and in the course of time the adoption of this system will be general, if not universal.

The only other method of malting in Britain (excepting such minor modifications of drying as produce the various coloured malts), is the gelatinisation process. This was invented, comparatively recently, by Messrs. Gillman and Spencer, since the abolition of the Malt Tax. The industry has already attained considerable dimensions, for many hundreds of tons of rice and other grains are gelatinised every week. Rice is incapable of being malted by any ordinary process, but when gelatinised, it forms a singularly fine and useful ingredient in the manufacture of beer. Some of its advantages are its entire freedom from the evils inevitably present in malt, for no matter how much care be given to the cleaning of barley or purification of air and water, mould-spores, and germs of other low organisms are always left in malt. The conditions absolutely essential to the right growth of malt, are also those most favourable to the reproduction of all such organisms. The free use of antiseptics does not entirely overcome the difficulties naturally arising from such a state of things, consequently grown malt must be always liable to this defect.

Gelatinisation effectually avoids this difficulty, for rice or any other grain which undergoes the high temperature and pressure of gelatinisation cannot have clinging to them a single vital spore or germ.

This process of manufacture resembles malting only in the fact that the grain to be gelatinised is steeped. In common malting, corn is steeped for fifty or eighty hours, but by this method six or less hours suffice. It is then steamed under heavy pressure for a short time in a closed vessel of cylindrical form, from which it passes to the kiln to be dried. These kilns are patented, and are both novel and effective. The furnace and ensuing walls are of brick. The floors, which are of woven wire, rotate slowly over a series of drums, so that the moist corn is constantly fed from the top hopper, and whilst slowly progressing, is robbed of its moisture, and exposed to as much heat as may be desired. It finally reaches the bottom, and is discharged into the bottom hopper, from whence it is conveyed to any desired position for cleaning, sorting, and grinding.

It will be noticed how very greatly this process differs from common malting, and how completely it depends upon mechanical aid

The changes produced in rice by gelatinisation are indicated by the following analyses:—

	Raw rice.		Gelatinised rice.
Water	12·51	..	9·63
Starch	74·81	..	77·22
Dextrine and sugar	1·11	..	2·96
Soluble albumenoids	·41	..	·13
Insoluble „	8·78	..	8·62
Cellulose	·76	..	·33
Fat	·78	..	·43
Ash	·84	..	·7

The rupturing of starch granules by combined high temperature and pressure, and the essential empyreumatic flavour given by high kiln drying in direct contact with the products of combustion, are not capable of tabulation. They, however, constitute the chief value of the process; the points of superiority, in addition to those already enumerated, are its remarkable rapidity and certainty of action. Grain can be received, steeped, steamed, dried and ground entirely ready for use in eight hours (common malt takes from ten to twenty-one days). Every kernel, when gelatinised, is subject to precisely the same conditions of moisture, heat, and exposure, enabling the brewer to know accurately the composition of his wort, an element of uniformity impossible of attainment in ordinary malt.

All grown malt has invariably a large excess of diastatic power. Gelatinised malt is deficient in this respect, but whenever used in conjunction with common malt, the excess of

diastase present in the mash tun is invariably sufficient rightly to convert the starch of the gelatinised grain. The high pressure and heats adopted during the process of gelatinisation effectually rupture the granules of starch, making the constituent molecules enter freely into contact with the diastatic wort, which rapidly effects the change of starch into the saccharine compounds essential in worts. The peptonising influences of gelatinisation aid materially the formation of a wort duly containing the soluble albumenoids in that nice equilibrium so essential to the healthful growth and reproduction of yeast. Upon this growth the success of the brewer's operation so largely depends. The old belief in the superlative importance of fermentation in brewing has been freely questioned for some time. It is attributing causes to effects. It is now beginning to be accepted as true that fermentations are controlled greatly in the malthouse and mash tun. The power to gelatinise such nitrogenous grains as rice, or starchy material as maize or wheat, adds immensely to the power of a brewer to control properly his fermentation. To the general public such control has the direct advantage of improving the quality of the beer produced. Rational cultivation of the yeast is invariably and absolutely an improvement in beer, perceptible to the consumer.

The power to use other materials than malt in brewing may not be a decided advantage to farmers, but they should not have clamoured so loudly and long for the repeal of the Malt Tax. Good rice, or maize, is quite as well able to produce pure beer as sugar.

Rice is malted in Japan in a very curious manner, which has been fully described by Prof. Atkinson in the Memoirs of the Science Department of the University of Tôkio, in "The Chemistry of Saki" (1881).

The importance of this industry is indicated by the fact that nearly 6,000,000 barrels of saki are produced annually in Japan from koji and rice. This saki produces nearly twice the alcoholic strength of English beer. Koji is simply rice diastased by the growth of mould upon the exterior of the rice kernel, the growth of mycelium having a very similar effect to the development of the acrospire in growing grain.

III.—The Crude and Finished Products.

Although malt is in itself, in some senses, a finished product, it is at the same time simply raw material for further use in the arts and manufactures. Certain very small quantities are eaten as food, without further preparation, but the bulk of malt made becomes the raw material to brewers and distillers. This is simple and self-evident, yet it is most difficult to convince maltsters that it is so. Fortunately, empirical methods of producing malt have caused certain rules to be established and recognised, which make malt sufficiently good for use, but nevertheless, it remains a standing disgrace to our vaunted intelligence as a nation, that millions of bushels of valuable grain are annually passed, through processes of delicate and critical character, exerting most subtle influences, by men who know absolutely nothing of what they are doing. In 1877, over 60,000 bushels of malt were so utterly spoiled in Britain, that the officers of Excise allowed it to escape payment of duty, and every year—before and since—large quantities of barley have been similarly spoiled in process of manufacture. Such a thing is discreditable in the highest degree; for, given a man who knows live barley when he sees it, and who has sufficient knowledge of the conditions necessary to make that barley grow, and the power and skill to control rightly those conditions, it is simply certain that good malt will be produced.

In addition to this, much malt is made year by year which, although not positively bad enough to be rejected as malt, is nevertheless poor rubbish compared with what it might or should be, and losses constantly occur which are altogether avoidable. Indeed, there is no other industry which stands so greatly in need of reform, and of a due infusion of intelligence and knowledge, as that of malt-making.

The few direct products of a maltster are—malt, combes, and dust, none of which are waste products.

Malt is either white, pale, amber, crystal, blown, or black. Of these, the first three—white, pale, and amber—are made in the manner I have outlined, and the sole differences between them are occasioned by the barley from which they are produced, very slight modifications of growth, and chiefly by the methods of drying. White malt is made from the palest barley, worked in the best manner, and dried with great care. It never reaches a temperature exceeding 180° Fahr. at any time, except in singularly good kilns, and is kept carefully below 120° so long as 10 per cent. of moisture remains in it. Pale malt is almost identically treated, but may be a darker barley, and carried to a temperature

of 200° or even 230°. Amber or imperial malt is common barley very frequently mismanaged, or discoloured from various reasons, chiefly by neglect during the drying process, or it is intentionally carried to a higher heat upon kiln.

This question of heat upon kiln is one of great importance, and affects all users of malt in every operation. Experience has long taught that according to the heat of the malt upon kiln, the stability of the beer produced could be accurately regulated; indeed, Combrune wrote very clearly upon this subject 125 years ago. More recent writers have further pointed out that still greater influence is exerted upon the vitality and constitution of yeast-cells, by differences of only a few degrees upon kilns. Yet, in some of the largest and newest malthouses in Britain—even in Burton itself—we find differences of temperature in the malt greater than those needed to make white into pale, or pale into amber malt, if applied at an early stage of drying. Indeed, the differences in temperature that will convert pale malt into amber or imperial, are actually less than are to be found, in the vast majority of kilns, in the temperature of that pale malt lying in contact with the tiles or wire, and the upper surface exposed to the air. There are probably few kilns in England (having only a single floor) in which this difference is less than 50°. Pale malt next the tiles will be at 200° Fahr., and upon the surface 150°, or less; and malt heated to 240° would make amber or imperial malt, unless it was nearly dry.

Crystal malt varies still further, as it is green malt, not fully grown, taken straight from the floor, placed in a woven-wire cylinder, over a fire, and rotated. The curious sweetness of crystal malt to the palate may be readily accounted for by the mode of its drying. Sufficient moisture is present at high temperature to enable the soluble albumenoids to convert a portion of the starch into sugar, for as the malt when first heated is saturated with water, the amount of steam generated is considerable.

It is a very common opinion that malt contains much sugar, because of its sweetness. This is simply a popular delusion, as malt rarely has more than one-half per cent. of sugar, and often none at all. If the tongue and palate be dried, and malt flour be placed thereon, very little sweetness is detected; but the moment the saliva comes into contact with the flour, the peculiar and well-known sweetness of malt is perceived, as the diastase can then act upon the molecules of starch, and conversion to sugar instantly commences.

The following analyses show the value of the changes induced by malting, in the different classes of malt already mentioned:—

Composition of Barley and Malt (Oudemans).

	Barley.	Pale Kiln-dried.	Sun-dried or Air-dried.	Amber.
Starch	67·0	58·6	58·1	47·6
Dextrin	·5·6	6·6	8·0	10·2
Sugar	0·0	0·7	0·5	0·9
Albumenoids	12·1	10·4	13·6	10·5
Cellulose	9·6	10·8	14·4	11·5
Fat	2·6	2·4	2·2	2·5
Ash	3·1	2·7	3·2	2·7
Products of torrefaction	0·0	7·8	0·0	14·0

The following analyses of barley, and of malt, prepared from the same grain, were made in the course of last year by the late regretted Mr. G. W. Wigner, and his colleague Mr. R. H. Harland:—

	British.		Smyrna.	
	Barley.	Malt.	Barley.	Malt.
Starch	68·04	65·22	63·54	57·08
Dextrin	1 71	5·43	2·00	5·30
Sugar	0·00	5·78	0·00	5·56
Albumenoids, soluble	2·27	4 03	5·07	5·77
,, insoluble	4·03	3·32	4·03	3·68
Cellulose	3·96	6·00	6·04	7·62
Fat and oils	2·67	2·26	2·24	2·59
Ash	1·25	2·30	3·20	5·32
Extractive matter	3·39	0·00	2·00	0·00
Moisture	12·68	5·66	11·88	7·08
	100·00	100·00	100·00	100·00

Per-centage of nitrogen in albumenoids—

Soluble } Insoluble	1·01	1·18	0·812 / 0·644	0·922 / 0·588

The most noticeable feature in these analyses is the slight amount of starch actually converted to sugar in malt, and the readjustment of the molecules composing the starch and soluble albumenoids, commonly called diastase, in such a form that the conversion of starch into sugar is readily effected by the addition of moisture. It is probable that the amount of sugar indicated is in excess of the true amount ever present in dry pale malt.

Blown, brown, flare, or porter malt has the

still further difference that considerable heat is applied with suddenness before it is dry.

It is well known that any given temperature over 100° Fahr. will give much more colour to moist malt than a much greater heat could give to the same malt if nearly dry. Blown malt, accordingly, whilst wet, is exposed to the flare of fast-burning oak faggots, or billet wood, and gains much colour, flavour, and increase of size in consequence. It is laborious and difficult work to dry this malt, as the kiln floors are usually close to the fires, and the heat is trying to anyone unaccustomed to it. The public taste for porter and stout, or "black beers," is steadily increasing, but the consumption of this sort of malt is deservedly falling away.

Black, burnt, or patent malt, is pale or other malt dried in the ordinary way, and then placed in a cylinder over a fire, and kept constantly and regularly turning. The starch and saccharine constituents are speedily caramelised, and a splendid deep colour is obtained, which is communicated to porter and stout. The chief difference in the appliances used in the manufacture of crystal and black malts is the construction of the furnaces and cylinders. These have to be made in such a manner that free inspection of the malt can take place during roasting. They must also admit of ready lateral movement, to facilitate filling and emptying; and appliances for proper cooling are of importance. This manufacture is a singularly clear illustration of the apparently inevitable tendency of restrictive legislation to create close monopolies, for, owing to the high duty on malt, it was imperatively necessary to guard strictly against the loss to the revenue of barley being roasted which had paid no duty. Accordingly, a malt roaster was hedged in by law as jealously as a distiller, with precisely the same result—the creation of a close monopoly.

Gelatinised malt resembles other malt in practical use, so far as its place as a raw material in the brewery is concerned, with the chief exception of its diminished diastatic power, and its freedom from husk, which formerly occasioned a slight difficulty in use.

Wheat malt would doubtless be much more largely made and used, especially at the present price of wheat, were it not for the difficulty of growing it with the acrospire outside the husk. Further, its excess of gluten, and other nitrogenous constituents, give brewers much trouble in their existing state of knowledge.

Oats, when malted, also labour under the latter disadvantage to a very large extent, and in comparison with wheat and barley, they are, ordinarily, dear. Otherwise they malt freely, and if brewed properly, make delicious beer.

Combes are the rootlets of the barley. They remove from the kernel a large proportion of the ash and nitrogenous matters, as they consist of 30 per cent. or more of nitrogen compounds, with 6 to 8 per cent. of ash. They also contain a great diversity of acids and other substances. Lermer detected upwards of twenty distinct compounds in the samples he examined. They form good food for cattle and sheep, far better than any common food, and are much cheaper. Few farmers seem to be aware of their true position in this respect.

Kiln dust is a very minor product of malting, but is of use to farmers as manure. It consists of the combes or rootlets which fall through the wire or perforated floors of kilns, mixed with the dust and ashes carried by the ascending column of air from the fires and then deposited.

The uses of malt are becoming more numerous, as it is found to be of considerable value for a variety of purposes. Of its use by brewers, distillers, and vinegar-makers, every one knows, and its value to these traders is great. Its value to the agriculturist is, however, problematical. For bread and biscuit-making, for various extractive condiments and medicines, we are still, as regards malt, in the experimental stage, and much remains to be discovered.

Malt bread is very palatable. It possesses the advantage of remaining moist and soft when several days old. It makes delicious toast, and altogether is of considerable advantage to sufferers from weak digestions, as it is practically partly digested food. To toothless infants who are fed upon starchy food, malt is a great boon, as, until the teeth are formed, children assimilate starch with great difficulty if at all, but if the starch is converted by the diastase of the malt prior to feeding, the infant can derive nourishment and strength from it.

The subject of malt-making is a large one, and very much more could be said concerning it. No industry more urgently needs to have shed upon it the searching light with which this Society has so conspicuously illumined numerous branches of human energy. When empiricism in malting

is at an end, and men are guided by the rational teachings and deductions of science, we shall have a very great improvement in all processes—improvements which will permit of great economies, in that true sense in which loss and waste are prevented, and every product is utilised to the fullest extent of its natural capacity.

The battle between ignorance, bigotry, and greed on the one side, and knowledge, freedom, and true wealth on the other, has always raged and with varying success, but usually with the result that knowledge eventually conquers. It is greatly to be hoped that, now that malting can become a rational, and even scientific pursuit, it will afford another bright example of the benefit of freedom in strivings after perfection whenever and wherever efforts are made towards progress, retrenchment, and reform.

DISCUSSION.

Mr. JOSEPH FLINN could endorse, as a practical man, nearly all that had been said by the reader of the paper. He differed somewhat from Mr. Stopes, however, as to the temperature for curing white malts. Of course this depended on the kind of corn, and the time for which it was kept at the temperature employed; kilns with two floors were best for white or pale malt, and with such kilns he had been in the habit of using temperatures as high as 200° and 210°, without spoiling the colour, and the flavour of such malts could not be surpassed. He was having his kilns altered to this system before he knew Mr. Stopes, and he thought it was a matter of controversy which had the first kiln at work; as he was not an engineer, he was quite willing to let Mr. Stopes have the benefit of the doubt.

Mr. E. G. HOOPER objected to gelatinised rice being classified under the head of malt, particularly as it possessed very little active diastase. No one would venture to brew with gelatinised rice alone, which showed that the quantity of diastase must be exceedingly small, and he did not think, therefore, it was entitled to be called malt. Mr. Stopes said the only respect in which the processes were similar was that the rice was soaked and then dried, but he believed all scientific men would agree that by malt they had always understood a substance rich in diastase, and if gelatinised rice did not possess even enough to convert its own starch into sugar, it ought not to go by that name. He could hardly agree with Mr. Stopes that the malting process was more important than that of fermentation with regard to the soundness of beer; for it was pretty well established that the stability depended practically on the fermentation, during which process the beer was particularly exposed to the action of germs, which brought about decomposition. Pasteur had shown that almost any infusion of malt would keep perfectly well if it were kept from contact with putrefying germs. Another point, with regard to the quality of beer, was its flavour, and there again they had the distinct opinion of the ablest men, that the yeast brought in contact with it had a great deal to do with the flavour of the product.

Mr. A. W. GILLMAN wished to say, in reply to Mr. Hooper, that the derivation of the word malt showed it to mean melted or rotten grain. Some people would restrict the word malt to that prepared by germination only. Previously to the repeal of the excise laws, no other process was allowed, and that was no reason why it should not now have a wider signification. The essential conditions of malting were, diastasic power, the modification of the constituents of albumenoids so that they served readily for yeast food in the after process of brewing, and the imparting of empyreumatic flavour, by drying the corn in the presence of the products of combustion. In preparing gelatinised malt all these were present. Instead of the grain being steeped, germinated, and kiln dried, it was steeped, gelatinised, and kiln dried; and gelatinising produced very similar alterations in the constituents of the grain to those produced by germination; with this difference, that in the latter process there was almost always more or less acidity produced, because those grains which did not grow freely on the floor always became contaminated with mould or disease germs. In the other process that could not occur. The diastasic action, as had been proved by experiments described in the *Brewers' Guardian* for June 20th, was very distinct, and by continuing the process farther, it could be increased. Measuring it at the temperature most favourable to this action, 150° to 152°, it was found that about 25 per cent. of the starch was converted by the natural diastasic action of gelatinised rice malt, and that it was a true diastased action was shown by its being stopped by the addition of salicylic acid. The alteration in the albumenoids was evidenced by its use in brewing; the yeast, instead of being deteriorated as it would by the employment of raw rice, improved in strength. The other point, the addition of flavouring by the corn being dried in the presence of the products of combustion, was also a necessary condition of the process. It was not termed malt simply, but gelatinised malt, and in his opinion the day was not far distant when germination would become almost a thing of the past, inasmuch as there were natural imperfections connected with it, which he did not think even Mr. Stopes would be able to overcome. It would be as reasonable to deny that a steam-engine was an engine, or an electric telegraph a telegraph, because engines and telegraphs were known hundreds of years before steam and electricity were discovered,

as to say this material was not malt because it was not germinated.

Mr. SEBASTIAN DAVIS said that some experiments he had made during the last six months showed that by the addition of about 5 per cent. of maize to the malted barley, a greater uniformity and certainty in the after fermentation of the mash was secured. Two or three makers, one especially, had paid great attention to the malting of maize, and with great success, and when it was not burnt or hardened, but in a crisp state, so that it could be readily crushed between iron rollers, and was added in the proportion he had mentioned, it gave a fermentation which was remarkably uniform. About twelve months ago he tried it with great success for some time, and then not being able to obtain it for six months, he discontinued the experiment, but recently he had taken to it again, and found it very useful. His preparation, he might say, was intended for the manufacture of vinegar. A brewer had not quite the same experimental opportunity of obtaining the same result or data for observation, as he arrested the fermentation when the specific gravity was down to about 1018, so that he could not trace the full effect of the addition of a certain quantity of malted maize. He wished to show that fermentation was not entirely dependent on the temperature, but on the food supplied to the germinating cellules of the yeast plant.

Mr. JAMES DEATH, jun., wished to emphasise the value of the pneumatic system of malting, which he thought would be generally adopted in the near future. He had had some experience in brewing, both in Australia and Egypt. This system had been tried in Melbourne, and though at first there was a pre udice against it, its merits were soon recognised, and the article produced fetched 4d. to 6d. per bushel more than ordinary malt. A great many improvements would have to be introduced in a hot climate, brick walls being unsuitable; and he should prefer the walls of the house being double, so that the internal wall could be kept cool. The advantage of not having to keep the malt so long in stock had been insisted on; and to show the importance of that, he would hand up a specimen of malt which had been kept nine months in Egypt, which was entirely spoiled by weevil. By this process, the malting season could be extended one month each way, so that the amount of stock required could be considerably reduced. In tropical climates, where brewing was carried on by means of ice, he thought it would be quite practicable to carry on malting all the year round. The use of gelatinised grain was already very extensive, over 100 tons a week being made, and it would further extend if it could be produced more cheaply. A new process would shortly be introduced, by which the brewer himself would be able to gelatinise and dry grain on his own premises. and thus obtain it at a cost of 26s. or 28s. per quarter of 3 cwt. The capital required would be only from £40 to £60 for a 12-qr. brewery; and since the plant could be turned to other purposes also, the outlay would be practically *nil*. Prior to leaving Egypt, he saw in the Boulak Museum the figure of a man in the attitude of preparing *bousa;* it was labelled in the catalogue, "Brewing funeral paste," but he believed the man was really brewing beer, and if so, the antiquity of brewing would go back to the earliest dawn of history.

Mr. ALFRED TOMKINS said there were many kilns at present constructed in which the draught was not sufficient to carry off the moisture rapidly, and he rather thought some of Mr. Stopes' efforts had taken the wrong direction, and that instead of having a double floor, it would be better to have a single floor on which the quantity dried at one time was reduced, and the rapidity of the draught passing through the kiln was increased. In using the double floor, the green wet malt was put on the top floor, and that which had been dried there came down on the lower one, where it ought to have a good heat; but it had to be kept down for the sake of the upper floor, or else resort was had to a plan of putting cones into the malt being dried, which were simply metal tubes to allow the heat from below to pass through freely The effect was to increase the draught through the lower floor, but it killed the draught through the grain which ought to be drying on the top floor. The aim should be to increase the draught so much that the moisture should be carried straight away. If you could reduce the difference in temperature between the upper room and the top of the malt which was being dried to about 10°, and had a rapid draught, you would make better malt than with a double kiln.

Mr. INSKIPP said the pneumatic kilns with which he was acquainted (Beeston) worked very successfully, one in particular had been at work during the whole of last summer, which was a pretty severe test. The malt produced always fetched a higher price in England. Several patents had been taken out for this method, the first, in 1842, by an Englishman named Stead, but it did not prove successful. Since then there had been several foreign patents, but the main features in all were the same, the cooling and moistening of the atmosphere, drawing it through the grain, and preventing acidity and mould. He had no doubt it would be specially applicable to the colonies and hot countries, where brewers would be able to make their own malt.

Mr. A. O. STOPES said his experience ot two-floor kilns was that if loaded at the proper time, and if the regulation were properly attended to, there was no difficulty with regard to the ventilating of either the top or bottom floor. He had two at work, and knew the improvement in the malt from every point of view.

Captain CAMERON corroborated what had been said by the last speaker. He was now using a two-floor kiln, and the cones in the top floor were never required except to let the malt down on to the lower floor. He considered this the greatest practical improvement in malting which had been made for many years.

The CHAIRMAN, in moving a vote of thanks to Mr. Stopes, said this was a very important question. Some years ago, when he was in the House of Commons, he used to listen, year after year, to the debates on the repeal of the malt tax. The "farmers' friend," as he was called, used strongly to advocate this measure, alleging that malt could be largely used for the feeding of cattle, which could not then be afforded. However, this had not proved to be the case, but on the other hand it now appeared that the malt tax caused an increase of price of about 4s. a quarter of barley. Malt had certainly been used for other purposes, but as yet only in so small a quantity as to be hardly worth calculating. He had eaten very excellent bread made from malt, but it was not likely to be largely used on account of its cost.

The vote of thanks having been carried unanimously,

Mr. STOPES, in reply, said malting was a very important industry, as he had attempted to show. It had exerted a great deal of influence in the past, and he had no doubt that it would do so still more in the future. It would be found that a great deal of very useful food could be prepared in a much better manner by malting corn, instead of using it as at present, and it would be of great use medicinally. It would also be of great use to farmers in feeding stock, and he hoped one result of the paper and discussion would be that malt-making would be better understood. Although he had always claimed to be the first to introduce the double system in England, he had always given Mr. Flinn credit for being equal with him, if not a little before him. He laid claim to very little inventive genius in the matter, for he owed very much of what he had done to the suggestions of Professor Graham in his Cantor lectures. With reference to the use of gelatinised rice as malt, the subject had already been so much discussed, that he would not enter into it again, at length. He maintained that rice prepared by this process was to all intents and purposes malt, and he felt bound to include it, therefore, in the paper. He did not say that gelatinised rice was exactly the same as malt, but they were so nearly alike that they ought to be considered together. With regard to the importance of the malting process as compared with fermentation, the latter was no doubt a most important process to the brewer, and in asserting the equal importance of the former, he did not mean to claim for it the superiority. Perhaps he had emphasised it more than he would have done under other circumstances. Houses for tropical climates would naturally be constructed differently to those in England, and he should certainly not use brick. The weevil was only one of the minor evils arising from long storage. Malt might be kept a long time free from weevil, but it was not by any means equal to and would not give as good results as if it were used earlier. He had no doubt the brewery at Cairo could make malt very well, and when he was there he advised the proprietor to lay out a certain part of his premises for malting. He had been much pleased by the remarks of Captain Cameron as to the success of the house he had put up for him. In reply to Mr. Tomkins, he would say it was very necessary to have the heat which went out from the under floors pass through the upper floor; there was no waste heat, as the whole of the moisture from the upper floor was removed free of expense.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

H.R.H. the Prince of Wales, as President of the International Inventions Exhibition, has delegated to a Commission selected from among the members of the Executive Council, the duty of making arrangements for the effective carrying out of the work of the International Juries.

This Commission consists of:—Sir Frederick Abel, C.B., D.C.L., F.R.S. (Chairman); Sir Philip Cunliffe-Owen, K.C.M.G., C.B. C.I.E.; Sir George Grove, D.C.L.; Sir Edward James Reed, M.P., K.C.B., F.R.S.; Mr. John Robinson; Mr. R. E. Webster, Q.C.; with Mr. Trueman Wood, M.A. (Secretary of the Society of Arts), Secretary of the Commission.

His Royal Highness has expressed his wish that, as was the case in the International Health Exhibition last year, the exhibitors should themselves aid in the selection of jurors, by submitting the names of those gentlemen whom they may consider most eligible.

Exhibitors will, therefore, be asked to send in on a form, to be provided for the purpose, names of gentlemen who might be invited to serve as jurors. The actual selection of jurors will rest with the Jury Commission, who will endeavour to give full weight to the opinions expressed by exhibitors, but will not be restricted to the list of names suggested.

MUSIC AT THE INTERNATIONAL INVENTIONS EXHIBITION.

The following particulars respecting the Music Division of the Inventions Exhibition is taken from an article in the *Times* :—

In its general purport the historical exhibition will resemble that of old musical instruments held at the South Kensington Museum in 1872, which, however, it will surpass both in completeness and scientific classification. For not only will beautiful and characteristic instruments of all ages and countries be exhibited, but the arrangement will be strictly chronological, thus showing the gradual development of art manufacture in this particular branch. The comprehensiveness aimed at will appear from the following list of objects, the loan of which is solicited: —1, stringed instruments with keyboard; 2, stringed instruments with a bow; 3, harps, lutes, guitars, zithers, dulcimers, &c.; 4, trumpets, horns, and other brass instruments; 5, flutes, oboes, and similar wind instruments; 6, organs and other instruments containing organ pipes and tongues of metal; 7, percussion instruments, such as drums, stones, cymbals, &c.; 8, mechanical instruments worked by handle or automatic mechanism; 9, miscellaneous—castanets, conductors' batons, metronomes, tuning forks, Æolian harps, glasses, &c.; 10, ethnological; 11, manuscripts (old scores, &c.), choir books, lecterns, choir staffs, and other ecclesiastical objects relating to choirs, printed books, &c.; 12, paintings, engravings, drawings.

The last-named heading will comprise many interesting sub-divisions. Special attention will very properly be paid to the pictures of the patron saint of the divine art, St. Cecilia, a favourite subject with the painters of the Renaissance period from Raphael downwards. More authentic, although perhaps less beautiful, portraits of famous composers, singers, and instrumental virtuosi will also be exhibited. In addition to this a chance will be opened to contemporary talent by the admission of such modern pictures and engravings as deal with musical subjects, and notice will shortly be given to artists who may wish to send their works.

Almost as important as the historical collection will be the competitive exhibition of modern musical instruments to be held in the central gallery, where the drawings of the Art Schools were shown last year. Applications for space have been received from nearly all the English and many foreign firms of note, and allotments have accordingly been made by the sub-committee. The prizes will be assigned by a number of juries to be appointed by the Jury Commission. To facilitate the decisions of the juries and enable the public to judge of the excellence of the exhibits, a concert-room has been enclosed in the vicinity of the central gallery, and to this the various instruments will be removed in their turns, and their makers requested to have recitals performed upon them. By this expedient, the discordant noises involved in a simultaneous trial of several instruments in the respective allotments will be avoided, to the great advantage of judges, performers, manufacturers, and audiences.

Apart from the Exhibition of musical instruments, the art itself will receive ample practical illustration in many forms. The King of Siam, besides being an exhibitor, will send a band which will render its native music in the concert-room. For those to whom the strains of Eastern music would prove caviare a more congenial treat will, it is hoped, be provided by the engagement of the famous Strauss orchestra, which will discourse genuine Vienna valses and other eloquent music. The performances of military bands, which so largely contributed to the success of the Health Exhibition, will, of course, not be neglected. Competitions of choral societies and brass bands from all parts of England have also been arranged, and are expected to show a standard of popular musical culture at least equal to that of the French "orphéonistes" and "fanfares," and, at any rate, greatly superior to the terrible visitation which the country of Beethoven sends to our shores in the shape of the typical German band.

It is finally expected that the question of a fixed musical pitch will meet with attention, if not find its solution, at the forthcoming Exhibition.

Correspondence.

CHINESE SEWAGE.

In the discussion on Captain D. Galton's paper, "Metropolitan Sewage," I notice the chairman takes exception to the Chinese method of utilising sewage, as mentioned by Dr. Drysdale, and quotes Sir Rutherford Alcock's remarks upon its accompanying intolerable stench. It should be remembered, however, that the Chinese have two methods of dealing with excreta. In one case it is conveyed by means of coolies, or boats, direct from the houses to the fields; in the other it is dried, broken up, and packed in bags for conveying to a distance. In this latter state it is perfectly dry, hard, and inodorous.

In dealing with a low-lying and densely populated district like that of London, it certainly does not seem amiss to examine the conditions in other countries, similarly situated, like China and Japan. Having personally observed, with ever increasing wonder, the rapid succession of heavy crops obtained in these countries by its use, it has always been a matter of surprise to me how utterly neglected it has been in this country. Yet, if there is one tree in a garden or orchard which bears better than its fellows, ten to one you will be told that its roots have worked their way into some old sewer or cesspool.

The Japanese net the herrings, which frequent

their northern coasts during the spring, in immense quantities. These after being boiled, to obtain the oil, are pressed into blocks about two feet square; these are then piled up in huge stacks for a time, then broken up and spread on mats to dry, and, finally, packed in rush or straw bags for exportation. In the south each bagful fetches nearly its weight in rice. Now, without going into the comparative values of these two manures, could not some similar mode of treatment be applied to our sewage, so as to make it into a marketable commodity? It could not fail to prove a great boon to the market gardeners round London, and the smell once removed all objections to its use would vanish.

One speaker mentions the value of a ton of sewage manure as being only 10s. or 12s., "which would not exceed the cost of carriage." I have seen London ash-pit manure conveyed at least twenty miles from town, the price of which could scarcely have been half that.

A. A.

Notes on Books.

PATENT-LAWS OF THE WORLD. Collected, edited, and indexed by Alfred Carpmael and Edward Carpmael, B.A. London: Clowes and Sons, 1885.

There has always been considerable difficulty in obtaining accurate information on the subject of the Patent-laws of foreign countries. The texts of colonial laws, and translations of foreign laws, have been pubilshed from time to time in the *Commissioners of Patents' Journal*, but, as Mr. Carpmael states in his preface, this useful practice has been for some time discontinued. The copies of the journal containing the more important laws went out of print, and were not reprinted; and besides, repealed enactments are sold without any warning that they are not in force. Under these circumstances, it is pretty evident that, in spite of the many excellent abstracts which have been published of foreign laws, it was not easy to get detailed information on the Patent-laws of many foreign countries. In the present collection, as Messrs. Carpmael tell us, the laws of the more important European countries have been re-translated, and also all translations have been more or less revised. There are no notes or comments, the texts of the various laws being alone given; but a very copious analytical index has been added, by means of which the inquirer can readily ascertain the manner in which various points of proceeding are treated by different countries. Besides the laws, there is given a translation of the International Convention for the Protection of Industrial Property, under which the Governments of Belgium, France, Spain, Italy, Portugal, and some others, formed themselves into a union for the above purpose. It is probably not generally known amongst English patentees that Great Britain joined this union by an Order in Council dated the 26th June last. The principal object of this convention is to allow the subjects of each of the contracting States to enjoy certain advantages in all the other contracting States. The most important provision is that any person who has lodged an application for a patent in one of the contracting States shall enjoy a right of priority for six months over all other applicants in each of the other States.

General Notes.

PARIS INDUSTRIAL EXHIBITION, 1885.—Information has been received from the Foreign-office, through the Science and Art Department, that the Industrial Exhibition organised by M. Ducret, President de la Chambre Syndicale des Industries diverses, at Paris, will be held from July to November, 1885, in the Galleries of the Palais de l'Industrie, which has been lent by the French Government to the promoters of this undertaking. The Organising Committee has decided to form three foreign sections, one for England, another for Belgium, and a third for Italy, in order that the processes adopted by French workmen may be compared side by side with the methods adopted in these different countries. By virtue of a decree published in the *Journal Officiel* of the 10th January last, the portions of the Palais de l'Industrie assigned to this Exhibition, have been constituted a bonded warehouse. Communications should be addressed to M. Ducret, at the Palais de l'Industrie, Champs Elysées, Paris.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

FEBRUARY 25.—"Past and Present Methods of Supplying Steam Boilers with Water." By W. D. SCOTT MONCRIEFF, M.Inst.M.E. W. ANDERSON, M.Inst.C.E., will preside.

MARCH 4.—"The Evolution of Machines." By Professor H. S. HELE SHAW.

MARCH 11.—"Exploration, and the Best Outfit for such Work." By Major-General the Hon. W. FIELDING.

MARCH 18.—"The Rivers Pollution Bill." By J. W. WILLIS-BUND.

MARCH 25. "Introduction of the Beet Sugar Industry into England." By Colonel Sir FRANCIS BOLTON.

Indian Section.

Friday evenings at Eight o'clock.

February 20.—"The Teak Forests of India and the East, and our British Imports of Teak." By P. L. Simmonds. Colonel Michael, C.S.I., will preside.

Foreign and Colonial Section.

Tuesday evenings at Eight o'clock.

February 24.—"The Spanish Gold-fields and the Mines of Rio Sil." By William Sowerby.

Applied Chemistry and Physics Section.

Thursday evenings at Eight o'clock.

February 26.—"Tempered Glass." By Dr. Frederick Siemens. Sir Frederick Bramwell, F.R.S., Pres. Inst.C.E., will preside.

Cantor Lectures.

Monday Evenings at Eight o'clock.

The Fourth Course, "Chemistry of Pigments." By J. M. Thomson, F.R.S.E., F.C.S., Lecturer on Chemistry at King's College, London.

Lecture I. Feb. 23.—Introductory. Nature of Colour. Division of Colours. White Pigments. Deleterious actions on such Pigments. Methods of counteracting such actions.

Lecture II. March 2.—Chemistry of Blue, Yellow and Red Mineral Pigments. Certain Organic Pigments. Special Pigments.

MEETINGS FOR THE ENSUING WEEK.

Monday, Feb. 23...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. J. M. Thomson, "The Chemistry of Pigments." (Lecture I.)

Surveyors, 12, Gseat George-street, S.W., 8 p.m. Adjourned discussion on Mr. R. W. Mann's paper, "The Enfranchisement of Urban Leases," and on Mr. H. Martin's paper, "Recent Proposals for Leasehold Enfranchisement."

Actuaries, The Quadrangle, King's College, W.C., 7 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Capt. Colomb, "Principles of British Defence."

Tuesday, Feb. 24...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Mr. William Sowerby, "The Spanish Gold-Fields and the Mines of Rio Sil."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Sidney Colvin, "Museums and National Education." (Lecture II.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr. B. Baker's paper, "The Metropolitan and Metropolitan District Railways," and on Mr. J. Wolfe Barry's paper, "The City Lines and Extensions (Inner Circle Completion) of the Metropolitan and District Railways."

Anthropological, 4, St. Martin's-place, W.C., 8 p.m.

Wednesday, Feb. 25...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. W. D. Scott Moncrieff, "Past and Present Methods of Supplying Steam Boilers with Water."

Geological, Burlington-house, W., 8 p.m. 1. Prof. W. Boyd Dawkins, "A Dredged Skull of *Ovibos moschatus*" 2. Mr. Frank Rutley, "Fulgurite from Mont Blanc." 3. Mr. Frank Rutley, "Brecciated Porfido-rosso antico." 4. Mr. Arthur W. Waters, "Chilostomatous Bryozoa from Aldinga and the River-Murray Cliffs, South Australia."

Royal Society of Literature, 21, Delahay-street, S.W., 8 p.m. Mr. R. B. Holf, "Lucifer, as Pourtrayed in the 'Festus' of Mr. Bailey."

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. C. O. Burge, "Indian Railway Construction and Maintenance."

Thursday, Feb. 26...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Chemistry and Physics Section.) Dr. Frederick Siemens, "Tempered Glass."

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Dr. Stainer, "Psalm Tunes and Hymn Tunes."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. C. Pfoundes, "The Folk Lore and Art of Old Japan."

Parkes Museum of Hygiene, 74A, Margaret-street, 8 p.m. Prof. H. Robinson, "River Pollution."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, "The New Chemistry." (Lecture VII.)

College of Physicians, Pall-mall East, S.W., 5 p.m. (Gulstonion Lectures.) Dr. William Osler, "Endocarditis." (Lecture I.)

Telegraph-Engineers and Electricians, 25, Great George-street, S.W. 1. Discussion on Mr. Illius A. Timmis's paper, "The Working of Railway Signals and Points by Electro-Magnets, &c." 2. Sir David Salamons, "Constant Electromotive Force in an Electric Circuit."

Ladies Sanitary Association, 22, Berners-street, W., 3½ p.m. Mrs. Shiel, "Physiology and the Laws of Health." (Lecture I.) "Prevention of Disease."

Friday, Feb. 27...Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. H. T. Turner, "The Gauging of Flowing Water."

Royal Institution, Albemarle-street, W., 8 p.m. Prof. E. Ray Lankester, "A Marine Biological Laboratory."

Quekett Microscopical Club, University College, W.C., 8 p.m. Paper by Mr. T. H. Buffham.

Clinical, 53, Berners-street, W., 8½ p.m.

Browning, University College, W.C., 8 p.m. Paper by Mr. Ernest W. Radford.

Saturday, Feb. 28...National Indian Association (at the House of the Society of Arts), 4 p.m. Annual Meeting, under the presidency of the Marquis of Ripon.

Physical, Science Schools, South Kensington, S.W., 3 p.m. Mr. James C. McConnell, "Notes on the use of Nicol's Prism."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Mr. C. Ambruster, "The Life Theory and Works of Richard Wagner," with illustrations. (Lecture I.)

Journal of the Society of Arts.

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FRIDAY, FEBRUARY 27, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The first lecture of the fourth course, on "The Chemistry of Pigments," was delivered by Mr. J. M. Thomson, F.R.S.E., F.C.S., on Monday evening, 23rd instant. In this lecture Mr. Thomson commenced by describing some relations between the colour of bodies and their composition. He illustrated this by the rapid conversion of black mercury sulphide into the red variety by boiling with ammonium per-sulphide. Allusion was next made to difference of colour with crystalline form as shown by the red and yellow varieties of mercury iodide. Mr. Thomson then passed to the consideration of changes of colour depending on the different states of hydration of substances, showing the many changes of colour which may, under such circumstances, be produced on certain cobalt nickel, and copper compounds. A selection of white pigments were next considered, and the changes produced on certain members of the group by noxious gases experimentally illustrated, and methods shown by which these changes might be hindered or remedied. Passing from the whites to the yellows, some of these colours were considered, and the formation of yellow and orange chromes illustrated. The lecturer concluded with the consideration of the yellows containing sulphur as illustrated by the arsenic and cadmium sulphides, and showed the advantages belonging to the latter colour. Collections of colours were lent for exhibition by Messrs. Winsor and Newton, and also by Messrs. Reeves.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

INDIAN SECTION.

Friday, February 20, 1885; Col. Michael, C.S.I., in the chair.

THE TEAK FORESTS OF INDIA AND THE EAST, AND OUR BRITISH IMPORTS OF TEAK.

By P. L. Simmonds.

The subject which I have to bring before the notice of the Indian Section of this Society this evening, is one of much importance at the present time, both to India and this country, especially from the fear our timber merchants entertain of failing supplies of that valuable ship-building wood, Teak. I have thought, therefore, it might be desirable to gather together such facts and information as would serve to throw some light on our past and future supplies of this wood.

The teak tree (*Tectona grandis*) is to be found in Bundelkund, on the Arrevalli and Sautpoora ranges, and on the banks of the Taptee river. It grows as a majestic forest tree, on the western side of India from Nasik, north-east of Bombay, southwards to Sevemdroog, in the forest west of Vingorla, in the forest near Sawant Wari, in the forests between Dharwar, Sunda, and Sedashegur, and in small patches above the Ghâts in Canara, Malabar, Cochin, Travancore, and Coimbatore, as also in the Annamullay Mountains. It is to be met with in small clumps in the Nulla Mullay Mountains, between Nellore and Cuddapah. North-east of this tract, it occurs in the provinces of Nagpur and Hyderabad, on the Godavari and its affluents, namely, east of Chanda, on the left bank of the Waingunga, and north of the Indravati river, in 20° N. Lat.; also on the 18° N. Lat., close to the right bank of the Godavari, east of the Warangal, and further east on the right bank of the Sebhir river.

In Burmah, and especially in the Tenasserim provinces, teak forests of great value abound, at the forks of the Salween river, and west of Moulmein, between the Martaban river and the Meinam, nearly as far south as Tavoy.

The Wynaad Government teak forests cover an area of about 100 square miles, and abound with valuable teak, besides other useful timbers, as Blackwood (*Dalbergia latifolia*), Hone (*Pterocarpus marsupium*), and Mutti (*Terminalia glabra*). These forests are a

part of the finest teak tract now belonging to Government in the Madras Presidency. The South Canara teak forests have been partially alienated from the State, and the Annamallay teak forests, which contain a finer growth than anything in the Wynaad, are a very extensive tract, of which a great portion is held by Government on lease. Mr. Dalzell, formerly a Conservator of Forests in the Bombay Presidency, published, a few years ago, an official report "On the Natural History and Biology of the Teak Tree," which is found from the 8th degree of S. Lat. in Java, to the Tropic of Cancer in N. Lat. 20° to 30°. There are no means of ascertaining what is the distribution of the teak tree in longitude, but it is not to be found farther west than 72° of E. Long.

The vertical range of teak is about 3,000 feet from the level of the sea. It is what may be termed a social tree, growing in groups, large or small. This circumstance renders it extremely valuable for trade purposes. Although this tree (as already stated) is very widely distributed, attempts, resulting in varying success, have been made for introducing its cultivation into those provinces of India to which it is not indigenous. In Bengal the teak has been planted with success for some fifty years or more, in the Nudder district, and of late years it has been introduced into other districts of Bengal. The tree is thriving luxuriantly in the Daood Kandy subdivision of the Tipperah district. This superb timber tree has its northern limit in Bundelkund, at elevations of 3,000 feet, ascending even to 4,000 feet, but then not of tall size. The wood is held in the highest esteem by shipbuilders, and for the backing of ironclad men-of-war is preferred to any other wood. It scarcely shrinks, and is considered the strongest and most durable timber of India, or, perhaps, even in the world, and resists the attack of white ants, the greenheart of British Guiana (*Nectandra Rodeii*) alone vieing with it.

From the reports given in the special Indian Catalogue of the late Edinburgh Forestry Exhibition, I find that in Jhansi and Lalitpur, North-West Provinces, teak is found scattered in dry mixed forests. In the Central Provinces, the Jagmandal forest reserve, with an area of 24,503 acres; the Chaurigogarh reserve, of 1,660 acres; the Airi forest reserve, of 2,150 acres; the Bareila forest reserve, Mandla district, of 7,153 acres; and the Pandratola forest reserve, in Balaghat district, 4,960 acres, contain chiefly teak forest. In Berar, part of the forest of Pargana Melghat, Ellichpur district, containing 272,000 acres; of the Gungumal reserve, of 115,200 acres; of the Penganga reserve, of 11,575 acres; and of the Kinwit reserve, Bassim district, of 52,558 acres, contain a large proportion of teak.

Specimens of teak from the Government plantations at Nilambur, of 100 and 103 feet long, by 93 and 100 inches in circumference at the base, were shown. These were planted in 1844 and 1847.

The only author I know of who has published any detailed account of teak in this country, is Mr. T. Laslett, timber inspector to the Admiralty, who, in 1875, in his work on "Timber and Timber Trees," devoted a chapter to the teak tree.

Since the above was written, I have seen mention of a work by Mr. J. H. W. Cordes, inspector of forests, published in Batavia in 1881, which I have not been able to refer to, entitled "Les Forèts de Jati de Java, leur nature, leur étendue, leur histoire, et leur exploitation."

In the last nine years, however, much new information has been published in various journals in India on the subject. Mr. W. L. De Sturler, in "A Descriptive Catalogue of the Woods of the Eastern Archipelago," speaking of the teak of Java (which there bears the name of *djati* or *jati*), observes:—"It has been asserted that several varieties of the teak tree differ essentially from each other in the bark, form and colour of the leaves, and in the character of the wood; but from a critical examination, one can only arrive at the conclusion that no specific differences exist, and that the deviations proceed merely from the physical properties of the soil on which the trees grow." The qualities of this timber certainly vary greatly according to the nature of the soil on which it grows. These differences are not confined to one part or other of the same country, but even in the limits of very circumscribed districts they will often be very considerable, and in others less, according to whether the tree has been grown on slopes, in the valleys, on sandy ground, argillaceous, calcareous, rich or poor in humus, alone or in the middle of thickets or forests, &c.; the wood will have a grain more or less fine, and have attained greater or less hardness. One tree will often differ so much from another, that this has led to the belief of distinct species, but a frequent close examination of different trees has shown that though varieties may exist, there is but one species.

Blume enumerates as many as ten varieties,

which he names *jati-douri* or *doeri*, *soungoi* or *soengœ*, *kompang* or *kembang*, *minyak* or *mienjak*, *kounir*, *preng*, *temeng*, *goair*, *lenga*, and *kapour*. Several of these designations are of purely local use, and not generally employed. The Javanese classification is the best, the names given to the varieties being characteristic of the qualities of the wood they distinguish, viz.:—

1. *Jati Soungou*, or horny.—The wood being of a dark chestnut brown, very firm, equal in grain, and of a fine tissue. It is the variety which has the most hard and solid timber of the best kind, and that most employed for ship-building and carpenter's work, and it is, at the same time, the most common.

2. *Jati Lenga*, or *Minyak*.—The wood of this variety is much darker, and veined in various ways. It has a greasy feel to the touch when worked, and sometimes there is seen on the surface oily drops as large as a pin's head, hence the name *lenga*, or oily. It is a very good carpentry wood, like the last named, but is not so common. It is much esteemed by the cabinet-maker, although not easy to work. These two varieties are much confounded as we reach the south in the central part of Java.

3. *Jati Kapour*, or calcareous.—This is fainter in colour and more tender in fibre than the two preceding varieties. It is brittle and less durable. The tissue contains much lime ordinarily diffused, and appearing in small crystals in the fibre. These sometimes form little rings; this substance is taken up by the tree when it grows on lowlands containing much disintegrated lime.

The following varieties are limited to special localities, such as Rembang, &c.

4. *Jati Doreng*, marbled or waved teak.—This yields the handsomest wood of all. It is much sought by the cabinet-maker, being hard and solid, but it requires some preparation, without which it splits and splinters easily, especially during the long dry season.

5. *Jati Eri, or Douri*.—Spiny teak, with small protuberances resembling thorns or spines; of irregular fibre; wood solid, hard, and difficult to work.

6. *Jati Krong*.—This variety has protuberances rather larger, and in form resembling shells.

7. *Jati Ourang*.—This variety has circular undulations on the surface of the trunk, resembling the articulations of shrimps.

8. *Jati Werou*.—This variety has a yellowish brown wood, rather shining. The fibre is equal and fine. The three last-named varieties are very useful.

9. *Jati Kembang*.—This is a characteristic or marked variety, but an accidental occurrence in some trees of particularly fine veins or markings, and a strong perfume.

Mr. Sturler enumerates the following varieties:—

1. *Djati Kapoor*, which grows on calcareous soils, as is shown by the calcareous veins which ascend the trunk. The wood, which in colour resembles oak, is neither too hard nor too compact in texture, but with extended fibres is easily worked. Its resisting force, according to Barlow, exceeds that of Canada oak, the specific weight being relatively 0·872 to 0·745.

2. *Djati Soengoe*, or true djati.—The wood of this variety is darker in colour, compact in texture, and more durable. It is generally used locally for house-building.

3. *Djati Doereng*.—This name refers to the thorns, or pointed excrescences, with which the trunk is garnished. The wood resembles the last-named variety, and is used for the same purpose.

4. *Djati Kembang*, or flowered teak.—The wood of this variety is brown, streaked, and of a satiny lustre. The concentric rings are irregularly waved. The timber is rather rough, and requires good tools to work it, but, notwithstanding, it possesses excellent qualities for naval construction and furniture.

5. *Djati Gembol*, or oily.—The wood of this variety is distinguished from the others by its unctuousness, which is apparent to the touch. The colour resembles that of the last-named, but the texture is more compact and the fibres more twisted, so that it is difficult to work. The annular rings are tortuous and very irregular. Its specific weight is much greater. It excels all other varieties, not only for ship-building and constructive purposes, but also for furniture.

In Java, the Government have under their control more than 1,650,000 acres of teak; that is without counting the new plantations of the State. This estimate was made from returns received in 1871. Official instructions were issued in 1865 as to the manner of planting and raising young teak trees, and on the mode of felling, classing, and measuring teak. New regulations were issued in 1875 for working the teak forests, and the forests of other woods in Java and Madura.

The teak tree grows spontaneously in the vast forests in the high central and eastern

regions of Java, covering an area of 3,000 miles, but it is difficult to get out, and hence can be obtained cheaper from Burmah. All efforts to cultivate it in other parts of the island, and in other islands of the Eastern Archipelago, have completely failed.

Mr. Nepean, Assistant Conservator of Forests in British Burmah, remarked recently that although it is known that there are upwards of 140 varieties of oak, about 21 of pine, divided into three genera, and many other important genera of trees which have been described and classified, yet only one species of teak is mentioned. He, however, distinguishes no less than six distinct varieties, and considers there are many more to be met with in the Wynaad, Coorg, or Mysore forests, and in British Burmah. It has been lately discovered that the teak found in Arrakan is 16 per cent. stronger than Maulmain timber, and the size and quality is excellent.

The Indian official report for 1881-82 shows how very successful forest administration has been in British Burmah, and how vast are the timber resources of that rich province. The total area of the reserve forests was 3,274 square miles; 836 square miles were added during the year, most of the new reserves containing more or less teak-producing land. Eight hundred and seventy-two acres of plantations, principally teak, were made during that year, containing over 600 seedlings per acre, and it is hoped this system may be carried out to meet Dr. Brandis's programme of 2,000 acres per year. Nineteen thousand teak trees were girdled in the year named, and it is calculated that 40,000 marketable teak remain. Revenue was collected on 76,000 tons, or 3,800,000 cubic feet, and free permits were given for over 42,000 tons of timber. This large yield only shows the out-turn of 31,000 tons of teak, and the 16 other reserved kinds, 87,000 tons; and is exclusive of all the other numerous species of timber; many of which are regarded as valuable trees in other parts of India.

One hundred and thirty thousand tons (6,500,000 cubic feet) of teak were exported from Rangoon and Moulmein; this including, of course, a large quantity from Upper Burmah. Of this timber, England took 50,000, and India nearly 80,000 tons, the exports to other countries being insignificant.

In Burmah, the timber trade has long been extensive, owing to the demand, in British territory, for wood for construction (all the houses in that province being built of wood) for ship and boat-building, and for export by sea. The higher slopes of the Himalayas, in Kashmir and in Nepal, the hills in the western country, just beyond our Western Punjab frontier, and those prolonging the Himalaya chain eastward to South-Western China and Siam, are clothed with the most magnificent forest vegetation, and are capable of supplying unlimited quantities of the best kind of timber. Where water carriage exists, as it does in Kashmir, Nepal, and Burmah, the trade can be conducted on a large scale, the cost of transport being inappreciable, as the logs are floated down the streams; but where such carriage is not to be had, these grand forests are, for the present, locked up, and inaccessible.*

The largest trade of Burmah is with Calcutta, owing to the great consumption there of teak timber, of which the quantity annually exported is said to be equal to 7,500 full-sized trees. The teak tree, though nowhere found in the low alluvial lands to which the tide reaches, abounds in the high lands, and seems to be very generally disseminated throughout the Burmese dominions, the forests of Pegu being specially abundant.

The principal teak forests are near the river Irrawady, and there is water conveyance for the timber, so that ship-building has been carried on since 1876, and ships of 1,000 tons and upwards are frequently launched there.

The imports of teak, by land, into India in the last three years, were as follows:—

	Tons.		
	1881-2	1882-3	1883-4
From Upper Burmah	29,679	48,632	39,867
„ Zimmé	31,259	52,376	45,501
„ Karennee	76,174	79,338	94,837
	137,112	180,346	180,205
	Value.		
	£	£	£
From Upper Burmah	106,860	205,101	232,046
„ Zimmé	132,803	229,378	197,470
„ Karennee	458,108	543,647	605,825

It is remarked in Mr. O'Conor's "Review of the Land Trade," that the decrease in the

* Report on the external trade of British India, by J. E O'Conor. Calcutta, 1880.

imports from Upper Burmah was due to a small rainfall which did not leave water enough in the streams to admit of floating the logs down. Though the Salween trade from Karennee has increased very much, by reason of the extension of forest operations, beyond the border, good teak has been difficult to get, and much of the imports consist of inferior logs of low value, hence the decline in the aggregate values.

Mature timber is getting scarce in the Moulmein forest, within easy distance of the coast. Some Burmese foresters have, in fact, it is said, crossed the frontier into the Siamese forests, those in British territory not affording sufficient remuneration for their labours. The Commissioner of Tennasserim, some few years ago, made the following remarks on this subject:—"Our timber trade, which, by care in reproduction within our own provinces, might, with the supply we get from Foreign States, have gone on flourishing for years, will now, I fear, gradually show a decrease. The quality of timber already shows a marked deterioration, as compared with former years." In 1855, we imported into this country 23,830 loads of teak, of which 15,712 only were from British India, and 8,100 of so-called teak from the west coast of Africa.

SHIP-BUILDING WOODS OTHER THAN TEAK AND OAK RECEIVED INTO LIVERPOOL.

Years.	Loads.	Years.	Logs.
1862	15,963	1877	3,823
1863	10,867	1878	2,309
1864	17,383	1879	931
1865	12,599	1880	953
1866	4,932	1881	1,016
1867	4,039	1882	3,921
1868	9,919	1883	1,480
1869	4,987	1884	—
1870	2,491		

Teak, for ship-building purposes, surpasses threefold in ordinary duration the best oak of Canada. A species of so-called African teak was formerly largely imported for ship-building. Long as this valuable wood had been known, it was only in 1850 that its botanic characters were determined, when it was named *Oldfieldia Africana*, after the gentleman who sent home some seeds, which vegetated at Kew-gardens. This timber partakes largely of the characteristics of both oak and teak. For some particular purposes in ship-building it is unrivalled, but its great weight prevents its general application. In 1841, we imported 13,126 loads of this wood, but the supplies have been gradually dropping off year by year, so that in 1860 only 1,173 tons were imported, and now it has ceased altogether. The waterside locations from whence it had hitherto been procured being exhausted, now it has to be obtained at some distance in the interior, and from the great difficulty there is in dragging it through the forest, rafting it down the rivers and creeks to the beach, and shipping it on board the vessel, the price becomes so enhanced, that little or no profit can be found in the disposal of it in England.

The following return gives the export of teak timber from India in the years ending 31st March respectively:—

Year.	Cubic Tons.	Year.	Cubic Tons.
1868	16,632	1878	56,962
1869	40,229	1879	37,487
1870	19,831	1880	38,622
1871	32,632	1881	65,626
1872	42,459	1882	56,377
1873	50,443	1883	59,187
1874	51,124	1884	46,471
1875	42,868	Six months to	
1876	60,612	Sept......	18,850
1877	45,108		

Out of the total exported in 1883, 55,519 tons were shipped from ports to British Burmah, principally Moulmein, the rise in price from £7 6s. to £8 9s. per ton was said to be due to the falling off in the supplies of first-class timber, and to the great difficulty which exists in getting the logs to market. The total output of teak in the year, as shown by the coasting trade exports, was 113,391 cubic tons. Bengal and Bombay receiving the bulk, Madras and Sindh taking only 15,000 tons, Great Britain took about 49,000 tons, and small shipments were made to Gibraltar (probably for orders), Ceylon, Sumatra, the Straits Settlements, and the Cape Colony. In 1884, 122,861 cubic tons of teak were brought coastwise into India. This is all sent from Burmah to Bengal, Bombay, Madras, and Sindh, and the quantity thus consumed in the country is far larger than that exported to foreign countries.

The rise of prices and decrease in the quantity shipped abroad are an indication both of the increasing scarcity of this timber, and of the larger demand for it which has been created in India by the progress of construction. The scarcity, it must be said, is as yet manifested only so far as regards large logs; inferior and small logs are abundant enough still. Moulmein has already been deprived by

Bangkok of this trade which it possessed until recently. The value has more than doubled in the last five years, owing to the large timber, convenient to the rivers, having now disappeared.

The quantity of teak imported, by land, into India was, in 1880-81, 116,737 tons; in 1881-82, 107,433 tons; in 1882-83, 131,714 tons; and in 1883-84, 180,205 tons; valued at £1,035,340.

The system of "permits," under which the best and most easily worked logs were got out in large numbers, year by year, by private persons, has, with very few exceptions, been stopped, and the forests are now worked by direct Government agency. The successful plantation of teak in the northern Arrakan hill tracts shows that that district is capable of considerable productive power. It seems to be thought by some that the general use of iron for ship-building will interfere considerably with the India teak trade, but at present this does not seem to be the case, for, from its durability, teak is being used for deck planks. The best teak forests in British Burmah are on the hills between the Sittong and Irrawady rivers, and in the Thoringyen valley, but even these forests are poor compared with the extensive forests covered with teak to the north of the British boundary, especially on the borders of the Sittong and Salween rivers, and some of the tributaries of the Meinam or Bangkok river. The trees also are, as a rule, much larger, and the shape of the stem more regular in the forests of the Burmese empire, the Siamese kingdom, and the Karennee country. Trees 10 years old have usually a girth of 18 inches, measured at 6 feet from the ground; at 22 years a girth of 3 feet is attained, but full grown trees of 9 feet in girth cannot be supposed to be less than 160 years old. The tallest teak tree measured in Pegu was 106 feet high to the first branch.

Teak, though generally diffused throughout Burmah, is mostly obtained from the forests of Irrawadi, betwixt the high and low lands. Large forests exist on the Burmese boundaries of Siam. The logs, when dry enough to float, are made into rafts, and floated down the rivers to Bangkok, where they are usually sawn up. The most suitable form for exportation is planks, five inches in thickness. About 800 square miles are included in the area of the State forests of Pegu. The future yield of the teak production is carefully maintained and insured by a system of teak plantations, and by protecting the existing forests from fire.

In Siam, teak has not been found in large quantities south of latitude 16° North. The greatest supply to the Bangkok market arrives from the province of Sangabock. In 1870, 8,978 teak planks, and 2,674 pieces of teak, were exported. In 1873, 200 loads, the produce of Siam, were imported into London from Bangkok. Within the last twelve months the source of supply has been increased, and the exports have been considerable.

The finest teak plantation in the Madras Presidency, and, indeed, in all India, is that at Nilambur, on the River Beypore, in Malabar, which was formed by Mr. Conolly, in 1844, and in 1862, Mr. Ferguson, the late superintendent, took charge; he continued to plant 100 acres a year. The river is navigable to the sea, so that there are great facilities for the removal of timber. The largest trees are five or six feet in girth, with noble, straight stems, without a branch for sixty or seventy feet. Up to 1865, the number of seedlings planted was 1,678,679, occupying 1,696 acres, and at the rate of 1,000 trees an acre, there are now about 1,800,000 trees.

The yield in 1871 was 4,075 saplings, floated to the depôt at Calicut, being the thinnings of the plantation, which more than repay the annual outlay.

From the experiments of Major H. Campbell, it would seem that the density of teak wood ranges from 0·594 to 0·897, according to the quality and the mode in which it is seasoned. Captain Baker found it to vary from 0·594 to 0·792. It is evident, however, from the recorded results of various experiments, that the specific gravity of teak varies considerably more, not only between the wood of different forests, but even in different parts of the same beam. The result of experiments by Mr. Sepping on teak, obtained from the woods of Moulmein, gave the maximum at 1·056, minimum, 0·583; average, 0·711.

Mr. T. Laslett, in his work on timber (1875), gives the result of twenty-four experiments on Moulmein teak. The highest as ·910 and the lowest ·712.

Average of six specimens	776·66
" " "	808·66
" " "	777·00

The strength and density of teak timber will vary exceedingly, according to the locality where the tree is grown.

The extremes observed in preliminary experiments, were 40 and 50 lbs. per cubic foot, and 190 lbs. to 289 lbs. breaking weight.

Many more experiments are yet necessary to be made ere reliable data can be formed. The hardness of the Bombay teak timber arises from the silicious soil on which it is grown. By a more careful investigation of the soils, important discoveries may be made relative to teak and the kind or variety most suitable to commerce being ascertained, and that variety in the future alone be conserved.

Out of about 2,000 species of trees in India, barely 100 are exclusively used or known. The teak is the most valuable of all, for it is hardly ever affected by the violent and sudden changes of temperature which render so many Indian trees almost worthless.

In India, teak forests are divided into high teak forests, as in the Western Ghâts and North Canara, and scrubby teak forests as they exist in the Konkun. The high teak forest is felled every 80 or 120 years, the scrub teak is cut down every 15 years, the roots remaining in the ground and sending forth new shoots, which under favourable circumstances become as large as the parent tree.

August is the best time for felling teak trees. If the cutting were done while the cambium were unexpended, it would render the timber liable to the attacks of insects, which subsist on this fluid. There is another advantage also in felling at this period; the vessels of the wood are then wide and open, so that the timber is quickly seasoned, the water contained in it having a more easy means of escape.

The durability of teak timber grown in the Bombay and Madras Presidencies arises from large secretion of silica, hence it is unpopular with carpenters, whose best tools are soon blunted in working it.

The objection is less applicable to Maulmain teak, which is much softer and looser in texture, and contains less silica. In fact there is nearly as much difference in the grain of Moulmein teak compared with that of Bombay as there is between ordinary bone and ivory the former weighing on an average 42 lbs., and the latter as much as 55 lbs. to the cubic foot. The difference is owing to the drier climate and the slower growth in Bombay, as well as to the larger proportion of silica.

It has long been a matter of controversy whether fast grown teak is inferior or superior to slow grown teak, and the differences of opinion on this point appear to be due to the fact that those who use teak wood in large scantlings, as in ship-building, are in favour of fast grown wood, while those who work with teak in short proportions decide in favour of the slow grown wood. The superiority or inferiority appears to depend on the purpose for which the wood is required.

The imports of teak into London, according to the annual circulars of Messrs. Churchill and Sons, have been as follows:—

	Loads.		Loads.
1880	5,800	1883	9,800
1881	14,400	1884	16,000
1882	6,700		

They remarked in 1882, that the high cost of the wood was limiting the consumption to those uses for which no substitute can be found, and the demand was, therefore, likely to fall off. But this remark was contradicted in their report for the year 1883, which stated that the demand for teak had been unusually active, and it would appear for many other purposes than for ship-building. Prices continued high throughout the year, but they expressed the opinion that, with depression ruling on most of the ship-building rivers, a continuance of the large demand cannot be reckoned upon.

The import of teak into the port of Liverpool in the last few years, according to the brokers' circulars, have been as follows:—

Average of five years, 1873—1877, 244,709 cubic feet.

	Cubic feet.		Cubic feet.
1877	193,000	1881	106,000
1878	231,000	1882	215,000
1879	Nil.	1883	243,600
1880	189,000	1884	118,350

The appended figures show the quantities of teak exported to Europe in the last ten years, with the average price that it has brought in the London market:—

Years.	Loads.	£	s.	
1874	37,400	13	0	per load.
1875	48,400	12	10	,,
1876	43,100	11	5	,,
1877	41,200	10	15	,,
1878	40,600	10	0	,,
1879	24,200	9	10	,,
1880	51,700	13	5	,,
1881	56,800	13	10	,,
1882	47,400	13	10	,,
1883	25,400	14	15	,,
1884	—	—		,,

These are wholesale prices, to which may be added 25s. per load for cost of the consumer.

The following are the average prices furnished me by Messrs. Edward Chaloner and Co., of Liverpool:—

Years.	Logs. £	Planks. £
1875	$11\frac{1}{2}$ to 12	$8\frac{3}{4}$ to 12
1876	$10\frac{3}{4}$ „ $11\frac{1}{4}$	$12\frac{1}{2}$ „ 15
1877	$10\frac{3}{4}$ „ $11\frac{1}{4}$	$12\frac{1}{2}$ „ 15
1878	$9\frac{1}{4}$ „ 10	$8\frac{3}{4}$ „ $11\frac{1}{4}$
1879	$11\frac{3}{4}$ „ 13	$8\frac{3}{4}$ „ $11\frac{1}{4}$
1880	$12\frac{1}{2}$ „ $13\frac{3}{4}$	13 „ $13\frac{3}{4}$
1881	13 „ $13\frac{3}{4}$	13 „ $13\frac{3}{4}$
1882	$13\frac{3}{4}$ „ $14\frac{3}{4}$	$13\frac{1}{2}$ „ $15\frac{1}{2}$
1883	$15\frac{1}{2}$ „ 16	$15\frac{1}{2}$ „ $18\frac{1}{2}$
1884	$13\frac{1}{2}$ „ $14\frac{1}{2}$	14 „ $16\frac{1}{2}$

All per load of 50 cubic feet, calliper measurement.

In an official report made to his Government by the South Australian Commissioner at the Calcutta Exhibition, he stated that while teak from Moulmein had long been the favourite wood used for railway sleepers, the price had increased so enormously, that buyers would gladly welcome the importation of Australian jarrah; the comparative prices, judging from those furnished for teak by a leading firm of teak merchants at Calcutta, would be in favour of jarrah at that port.

	Teak.	Jarrah.
Scantlings, 5in. by 3in. and 3in. by 2in., per 50ft. ..	£12 to £15	£13
Boards, 7in. by 1in. and 7in. by $\frac{7}{8}$in., per 600 running ft.	£13 10s.	£10 10s.
Special lengths and sizes, up to 12in. by 8in., per 50 ft.	£22 10s.	£15
Greater lengths of heavy timber, per 50 ft.	£27 10s.	£16 10s.
Hewn timber, 12in. by 12in. and 14in. by 14in., lengths up to 35 ft., per 50 ft. ..	£20	£13 10s.

EXPORTS OF TEAK FROM INDIA.

Years.	Cubic Tons.	Indian Value. £
1875-76	60,612	469,636
1876-77	45,108	367,543
1877-78	56,939	456,114
1878-79	37,413	317,518
1879-80	38,620	333,934
1880-81	65,626	500,046
1881-82	56,377	506,791
1882-83	59,187	611,259
1883-84	46,471	525,447

In the last three years the shipments to the United Kingdom were :—

	Tons.
1882	48,989
1883	50,232
1884	27,559

The girdling of teak trees in British Burmah has been suspended since 1875, and the only teak brought to market from forests in British territory, is either obtained from trees previously girdled, or found otherwise dead in the forests, or is drift timber.

Teak timber does not, as a general rule, reach the market until two or three years after it has been girdled. Though the trade is steadily increasing, the traders' profits are lessening fast, the cost of extraction is higher each year, as the supply gets scantier and further removed; while the home and Indian markets are too overstocked to allow a proportionate rise in price.

The activity in the construction of State railways (some 10,000 miles are open in India), and the requirements of the constructors of the lines for sleepers, led formerly to a great demand in India, for wood from Upper Burmah, Kashmir, and Nepal; but teak is now too dear to be used for sleepers. From Upper Burmah a considerable quantity of teak timber is floated down the river. The more accessible forests are being exhausted, and hence there is a decrease in the imports *viâ* the Sitang. Much timber is floated down the Salween, as the following figures show—1879, 199,213; 1880, 127,543 tons; 1880, 109,080 tons.

The export of teak from the two principal seaports in British Burmah amounted to 115,806 tons in 1874-5, and 162,164 tons in 1875-6. At the commencement of 1876, the area of State reserves under teak in British Burmah was 335,880 acres.

The import of teak timber into British India from Karennee, which is floated down the Salween river to Moulmein, was in 1880, 116,736 tons; and in 1881-2, 107,433 tons; high prices ruled during the latter year in the Moulmein market.

The foreign trade of British Burmah is more important than that of any other province. It is conducted chiefly with Upper or Independent Burmah, by way of the Irrawadi, and is largely carried by the steamers of the Irrawadi Flotilla Company. The value of the timber brought in was given in the official returns as follows :—

Year.	£	Foreign Trade. £
1879-80	428,049	—
1880-81	397,597	—
1881-82	697,770	63,177
1882-83	978,125	83,608
1883-84	1,035,240	76,056

In the last-named year there was imported from Siam 1,836 tons of teak, valued at about £13,000, besides nearly 40,000 cwt. of wood for railway sleepers. A number of woods, the produce of the forests in the interior of Siam, might become of importance, were their qualities for marine or civil architecture sufficiently known.

Sir Robert Schomburgk mentions, among others, the *takieng*, which, as far as regards size and quality, he considered might become a rival to teak, possessing moreover the great advantage that it can be easily bent by artificial means. Very little is known of the tree which produces this wood, but it deserves a closer examination, in order to ascertain how far it might be profitably employed for naval architecture. Sir Robert stated that he saw at the building sheds of the king, a log of that wood being prepared for a war canoe, measuring 135 feet, perfectly sound and without a flaw. This wood is brought from the South-Eastern Provinces, and generally used for planking the bottoms of ships.

The red peema (*Lagerstroema macrocarpa*), found throughout Burmah and Tenasserim, yields a common and valuable timber, equally useful with teak. Touk-kyan *(Pentaptera glabra)*, also found in the teak forests, furnishes a very large and useful dark brown timber, equal to teak or oak, and applicable for similar purposes. Angely *(Artocarpus hirsuta)*, one of the woods recognised by Lloyds, stands next to teak in the estimation of shipbuilders. It is well suited for the floors and bottom planking of ships as high as the bends; but the fastenings, where not tree-nailed, must be of copper, as, unlike teak, it corrodes iron rapidly. It is confined in the Indian Peninsula to the west coast, being particularly abundant at an elevation of 3,000 feet in Malabar, Cochin, and Travancore, where it is much used for canoes, ferry boats, and house-building. The logs of this wood brought down vary in dimensions from 15 inches to 2½ feet in diameter, and from 20 to 35 feet in length, with merely the sapwood chopped off. Larger timbers are obtainable, but as the expense and labour attending their transit are great, they are converted into canoes and floated down the river. If no objection to the core exists, 2,000 logs on an average might be procured annually of the required dimensions.

Jackwood *(Artocarpus integrifolia)*, a tree of the same family, furnishes an excellent fancy and furniture wood, and is admirably adapted for boat-building. It withstands the action of the weather and attacks of worms. It lasts longer under water, when used in boats, than teak, and is far superior to that wood for the upper planking, where it is likely to come into collision with other bodies.

The following figures give the value of the wood exports of India in the last nine years:—

	£		£
1875-76	471,627	1880-81	545,853
1876-77	373,878	1881-82	566,717
1877-78	458,792	1882-83	671,116
1878-79	321,868	1883-84	579,937
1879-80	340,144		

These exports are principally teak; for instance, all other woods exported in the last-named year were but to the value of £54,000.

In 1833, we only imported 34 loads of teak from places within the limits of the East India Company's charter, and 13,624 loads from other quarters; in 1849, the Indian shipments to England had risen to 17,460 loads, out of a total of 27,702 loads imported.

In the following return, the first column shows the true teak imported into the United Kingdom, the other includes also the so-called African teak:—

	Tons.	Total.
1846	8,712	16,536
1847	7,982	15,660
1848	3,836	13,206
1849	17,460	27,702
1850	10,249	18,558
1851	13,806	23,460
1852	15,915	26,283
1853	6,843	14,931
1854	21,562	28,656
1855	15,712	23,830
1856	21,085	24,602
1857	26,748	31,602
1858	37,885	45,704
1859	24,096	28,769
1860	25,112	26,285

Later official returns only distinguish teak.

IMPORTS OF OAK INTO THE UNITED KINGDOM.

	Loads.	
1866*	8,917	38,640
1867	67,885	344,312
1868	8,121	44,603
1869	63,997	344,254
1870	93,660	514,957
1871	97,412	509,277
1872	108,789	583,291
1873	119,199	782,351

* Duty 2s. per load, free after March, 1866.

	Loads.	
1874	142,717	940,095
1875	91,394	563,071
1876	135,951	822,319
1877	120,118	746,695
1878	60,254	354,916
1879	59,061	304,554
1880	91,499	567,118
1881	87,881	524,733
1882	102,327	617,987
1883	116,262	707,573

Principally from Germany and North America.

The following Table gives the imports of teak into the United Kingdom in the last eighteen years, and although some years show a decrease, on the whole the supply keeps steady:—

Years.	Quantity.	Value.	Remarks.
	Loads.	£	
1866	35,724	342,101	Of this, 28,693 tons came from the Straits.
1867	12,644	123,582	Nearly all from the Straits.
1868	18,888	230,666	
1869	40,062	433,856	30,000 loads from the Straits.
1870	17,038	211,212	About half from India.
1871	23,353	276,313	18,829 from India.
1872	28,898	381,136	All from India.
1873	40,313	532,198	Nearly all from Bengal and Burmah.
1874	30,011	402,531	All from Bengal and Burmah.
1875	30,535	364,689	All from Bengal.
1876	35,266	416,945	850 loads from Straits.
1877	28,072	326,253	25,062 from Burmah, rest from Straits.
1878	37,990	373,094	270 from Straits.
1879	15,737	152,481	1,637 from other countries.
1880	33,863	410,434	All from Burmah.
1881	40,720	541,669	731 from Siam, rest from Burmah.
1882	41,152	529,544	39,862 } from British India.
1883	45,539	647,470	41,538 } from British India.

The greater portion of Burmah, even all the plains, is still one vast forest. The country is now what India must have been many centuries ago; still a Forest Department has been considered necessary, and large tracts of teak and other forests are being formed into strict reserves.

The teak forests in Tennasserim are always in small patches, here and there interspersed with tracts of quite a different character. Most of the larger trees have been cut out, but there is splendid young growth.

In natural forests, where teak is associated with bamboos and other trees, the number of first and second-class teak trees (above 4 ft. 6 in. in growth) rarely attains ten trees per acre over large areas.

Col. Beddome estimates that on alluvial soil the trees in the pure teak forest at Nilambur will reach maturity at from 60 to 80 years; that felling will be spread in each plantation over fifty years, and that the time of cutting (say at 85 years of age) the mean quarter girth will be 2 feet; the length of bole will be 70 feet, the mean cubic contents of each tree 280 cubic feet. He also estimates that at that age there will only be 60 trees to the acre, making the contents, per acre, 16,800 cubic feet.

From some calculations, made by Colonel Beddome, of the cubic contents of trees at different ages, we gather the following. Arranging them in groups of 10 years each, the following results are obtained:—

Age.	Height of tree, in feet.	Girth at base in inches.	Length of bole, in feet.	Mean cubic contents, cubic feet.
4-13 years	48·75	21·60	32·56	10·6
14-23 "	65·110	51·69	40·70	23·8
24-33 "	20·110	60·105	41·72	51·3

This gives us the cubic contents, at different ages, as follows :—

Mean Age.	Cubic contents in cubic feet.	Periodical annual increment in cubic ft.
9	10·6	1·1 to 9 years
19	23·8	1·3 from 9 to 19 years
29	51·3	2·8 ,, 19 to 29 ,,

The annual increment increases steadily to the age of 30 years, and probably continues increasing for a considerable time beyond it.

I have thus brought together some few facts and statements regarding this important Indian wood, and shall be glad if it leads to more practical information and discussion as to supply and demand, or other substitutes for it, than I am able to give.

DISCUSSION.

Mr. W. G. PEDDER said he knew very little of the subject of teak forests, although he had taken a great deal of interest in the forest department. He understood Mr. Simmonds to state that the difference between the value of teak timber from Burmah and that of teak grown in Bombay depended a good deal on the rainfall. Now, in the Bombay Presidency, below the Ghâts, where the rainfall was from 100 to 150 inches a year, and also above the Ghâts, where it was much less—not more than 30 or 40 inches—teak grew. He should, therefore, like to know whether the difference in climate made any difference in the value or hardness of teak. He might remark on the facility of teak for coppicing. All over Western India, teak was cut down from generation to generation, and it sprang up again from the stools, and that had in fact a great deal to do with the destruction of the teak forests. They had never been properly worked, but had been entirely left to this natural process of restoration; and although fine timber was often produced from the stools in this way, still he believed it was never equal to the original tree.

Mr. SIMMONDS said he attributed the difference in quality to the soil rather than the rainfall.

Colonel BEDDOME said the annual increment in the growth of teak, in the Malabar plains, increased steadily to 60 or 80 years at least. This tree continued growing up to 80 years, and probably to 120. The difference between Burmah teak and that from Malabar was that one was girdled. In Burmah, the trees were girdled a year before they were felled, so that they might float, and being a year in that state, all the sap ran out, and the wood was of a less density, and of far less value for dockyard purposes. He believed that was the only difference. The soil had nothing to do with it, and certainly not the rainfall, for wherever this tree grew there was a large rainfall. The girdling was only stopped because they did not want the timber. The forest there was so unhealthy that it was impossible to look after the timber for a year when felled, therefore it was girdled; its specific gravity would not allow it to float the same year it was felled. Having had charge of the Nilambur teak plantations for twenty years, from 1860 to 1882, he might say that they were close to the Ghâts, not very far above the sea level. In 1840, the Collector of Malabar, Mr. Connolly, though the necessity of planting would hardly have occurred to most men, conceived the idea of making plantations of teak; he felled many acres of straggling forest, and planted them with teak. The first planting was in 1842, long before any Forest Department was thought of. But it was not until 1844 that anything like a large plantation was formed, when about 100 acres were planted. The Forest Department did not commence anywhere until 1857, and then in the Madras Presidency; but between 1844 and 1857, Mr. Connolly planted 100 to 150 acres a year, and when his department took charge in 1860 there were 1,400 acres planted. Between 1857 and 1882 the plantations extended to 3,500 acres. The trees were planted 6½ ft. apart each way, giving 1,040 to the acre, and thus acted as nurses to each other. The first year they grew about 18 ft. high with large leaves, but no boughs. After the first year they got a tall stem about 18 ft. high with a few large leaves at the top, and being so close they protected each other. After nine years, they were thinned out about 29 per cent. and then again at various intervals, 20 to 25 per cent. till the sixtieth year or so, when there would be only sixty or seventy trees left per acre, which would then contain more than 100 cubic feet of timber each. Some trees already, which were only 34 years old, had upwards of 100 cubic feet, and at 60 years they considered there might be from 200 to 240 cubic feet in each tree, which would give thirty million cubic feet of timber in these plantations. The felling would commence probably in 1904, and the present stock (*i.e.*, that planted between 1842 and 1878) would last for about 84 years, giving 183,000 cubic feet per annum, even if each tree was taken at only 100 cubic feet.

The CHAIRMAN asked if Colonel Beddome would say anything about the *Eucalyptus* plantations.

Colonel BEDDOME said the growth of teak was very rapid compared to that of oak. For the first thirty years the trees grew chiefly upwards, after that time they began to swell much in bulk. In the sapling stage he calculated the growth was about 1 to 2 cubic feet a year; but after thirty years the growth was immensely accelerated, and they have been known to add as much as 5 cubic feet in one

year. It was calculated that teak grew four times as rapidly as oak. With reference to the *Eucalyptus*, that grew in a temperate climate, the seed being brought from Australia, and had been known in India before any plantations were started, a few trees being planted about Ootacamund. In the Neilgherries, the Forest Department had planted the *Eucalyptus globulus* almost to the exclusion of other species, and he considered it was the tree of the future. In growing these trees, they had been anticipated by Major Campbell, the executive engineer of the barracks, who planted many acres at Wellington station in the Neilgherries. This tree grew nearly four times as fast as the teak, reaching 100 ft. in five or six years; when he took over those plantations he extended them largely. They were on the extension of the Mysore plateau 7,000 to 8,000 ft. above the sea, the climate being quite temperate, and the soil being suitable. He could hardly say yet what use the timber would be, but if railways were made there, it would be very useful for fuel and as sleepers, and in Australia it was said to be a good building timber. As yet the oldest trees were only twenty to thirty years, and in Australia the timber is scarcely used till it is of great age, when it is as fine as teak. It was a most interesting experiment, almost more so than the teak growing in Malabar.

Mr. A. R. Macdonald said he believed that teak from the North Canara forest was the finest in India. That grew above the Ghâts about 2,000 ft. above the sea. As he understood Colonel Beddome, the plantations in Madras were near the sea level, so that there was that great distinction between them. Plantations which had been tried along the coast in North Canara had all been comparative failures, and it was only above the Ghâts, at a considerable elevation above the sea, that they succeeded. They failed almost entirely on the Kâlânuddi; there was one plantation, about twenty miles from the sea, where teak grew, but the trees were stunted and poor. He understood Mr. Simmonds to say that teak was not used for railway purposes; but he believed, for the railway connecting the port of Goa with the Southern Mahratta country, a large contract had been given to the Forest Department in North Canara for sleepers, and as far as the Dharwar frontier all the sleepers would be of teak. It was durable, and the easiest timber procurable. When he was in Cuba he found the sleepers on the railway were of mahogany, because that was the most durable and easily procured wood. The Canara forests would partly supply the Bombay dockyard and all local requirements for many years to come.

Mr. Martin Wood said it would be interesting to know what it was in the chemical composition of teak which enabled it to resist the attacks of the white ant; also what rendered it comparatively impervious to fire. In conversation once with an old resident in Bombay, noticing how closely the houses were packed together, he asked how it was that the frequent fires were not more destructive, and his reply was, "Oh, teak does not burn," meaning, of course, as compared with European timbers. He thought it was generally understood that teak did not grow to any purpose at a less altitude than 2,000 feet, but that seemed to be an error, as Mr. Macdonald said it did grow below the Ghâts in Southern Canara; he had seen teak on the lower Ghâts further north, but it was spoken of as jungle teak. With regard to the rapid consumption of this timber of late years, he had intended to put the question, more especially to the Chairman, whether by any means of planting and conservancy it was possible to overtake that consumption, and so maintain the supply of this invaluable timber. But this had been answered, to a great extent, by Colonel Beddome, who had showed that it was really possible to increase the growth within a reasonable period. At the same time, as shown at various points in the paper, it became a question of more or less accessibility. He had understood that there were immense supplies of teak in the district of Bustar, north of the Godavery, and attempts had been made to utilise it, but these were as yet unsuccessful, as there was great difficulty in removing it. The remarks of Colonel Beddome with regard both to teak and other woods, confirmed his strong conviction of the immense value of the Forest Department of India, and also the remarkable discretion and wisdom with which it was carried on. With regard to the use of *Eucalyptus* for sleepers, he had heard of its being tried and abandoned, chiefly on account of its being too readily accessible to the white ants.

Mr. Simpson said there were various kinds of *Eucalyptus*, there was the red gum, the sugar gum, and the blue gum, some of which were eaten by the white ants wholesale. There were, in fact, 83 varieties of the *Eucalyptus*; the jarrah timber of the Western Australia was not only impervious to the attacks of the white ant, as had been proved by scores of experiments, but it was reckoned the next thing to everlasting. He should be glad of some information with regard to the practice of girdling. Australian timber was an evergreen, whereas teak was deciduous; and they were told in Mr. Lazlet's work that trees were girdled in India for about three years, and then it took about another year before the timber got to England, thus making four years from the time it was killed. His idea had always been that the timber was girdled in order to allow the action of the leaves to pump the sap out of the tree, in order to season it, because if it were felled and left lying, it stood a good chance of being burnt. His own experience was that as soon as the leaves died and ceased to operate, the trees should be felled. Probably not one in 10,000 had the faintest idea of the vast importance of the timber trade to England, being to the amount of £31,000,000 to £32,000,000 per annum, and it was very gratifying to know that, within the limits of the empire, from Canada, India and the Australian colonies,

that our requirements might be procured. Mr. Simmonds said it was very desirable to know whether there was any timber likely to answer as a substitute for teak, which was, he said, held in the highest esteem for the backing of ironclad men of war. No doubt that was correct; but in Western Australia there was a timber called tuart, which could be obtained of large dimensions, which he ventured to assert was superior to all others for the backing of armour-plated vessels. It could not be split by any possible means, and if a rifle bullet were fired into it it would pass right through without splitting, whereas teak would always split. Now that there was an idea of augmenting the navy, it was as well that this important timber should be made known. It was spoken of by Mr. Lazlet in very high terms. With regard to the quick growth of *Eucalyptus*, he had tried many experiments with the jarrah particularly, and he might say there was no difficulty with new plantations; it was quite the other way, for so soon as the tree was felled, such an immense amount of seed was scattered on the ground, that as soon as the sunlight got to it, a hundred trees would spring up for every one that was cut down. The young jarrah would grow an inch per day. Red gum was very valuable in swampy ground, which it soon pumped dry; and he had known instances in Western Australia, in which—where the trees had been girdled and destroyed—the ground became utterly useless, from the simple fact that as soon as the trees ceased to draw up the water, the land became a swamp. It was very astonishing to him to hear that there were such great differences in the specific gravity of different specimens of teak. With regard to the burning, there was one timber in Australia, the blackbut, which would not burn at all, and the jarrah was very difficult to burn.

Mr. ANDREW BELL asked Colonel Beddome whether any experiments had been made with the timber from trees which had been longest planted on the banks of the Bhapore, and how it compared with that grown in the Annamullays, which was formerly used extensively by the East India Company for their navy. That was of very high quality, very dense and strong. With regard to the *Eucalyptus*, he had heard or read that the leaves or branches had some peculiar property of freeing the air from the miasma which produced jungle fever, and would like to know if that were correct.

Colonel BEDDOME said this notion did formerly prevail, but it had now been abandoned. There was a strong smell of camphor, and in Australia it was found to be efficacious in fever; but the secret simply was that the trees dried up the swampy ground. In India it grew at an elevation above where fever prevailed. As to the quality of teak in the Nilambur plantation, grown at only 600 to 700 feet above the sea level, some timber had been sent down to the gun carriage manufactory and tested, and though there was no doubt that it was inferior to the teak of the mountains, still it was excellent timber. Teak in Bombay would not grow in the plains because there was a longer drought. Down in Malabar, Travancore, and Cochin there were two monsoons and a heavy rainfall, and the teak grew splendidly. Most of the teak in Madras was on the mountains, 1,500 to 2,000 feet elevation; still, very often indigenous teak was found in Travancore, down within 200 or 300 feet above the sea level, and he had seen specimens from 10 to 12 feet in girth. Van Rheede, who was a botanist and Governor of Malabar at the end of the 17th century, published a large botanical work, in which he mentioned the teak and its *habitat*, and spoke of it as growing *usque ad Calicutam*; but since he had known those forests there had been no teak anywhere near Calicut. The sole reason for girdling the trees in Burmah was to enable the logs to float, as this process reduced the weight seven or eight pounds per cubic foot. In no part of India had he known this process practised, and the Bombay Dockyard would not take teak which was girdled; they paid 2s. per cubic foot less for Burmah teak in the log than for Malabar teak.

Mr. SIMPSON asked at what period of the year girdling took place.

Colonel BEDDOME said, just before the hot weather. Jarrah timber was largely sent to India for sleepers, but he never heard that it was impervious to white ants, though it was to the sea-worm. White ants would eat anything. He had known the bottom of a deal box eaten through in a night; but teak, being so much harder, was not readily attacked until it began to deteriorate by the weather. Teak was not used for sleepers simply because it was too expensive. With regard to its inflammability, no wood in the forest burnt so readily when fresh cut. When first cut it was full of oil, and a few leaves would set fire to it, and he recollected the Chairman having a large stack of teak timber burnt and entirely destroyed.

Mr. MARTIN WOOD said teak sleepers were used years ago in India, and would be continued, but for the expense. Jarrah he had heard was very serviceable, but apt to shake. In future he believed that steel sleepers would take the place of iron, as being much more durable.

Sir JOSEPH FAYRER agreed with Colonel Beddome that the *Eucalyptus* had no special medicinal properties; but it was a rapidly growing tree, and it was a good thing to get a screen of trees between you and a malarious district. There was no doubt, if a plantation were placed between a settlement and a swamp, it would, to a certain extent, intercept the malaria, and also, as had been said, it did good by absorbing moisture from the ground, besides the influence which all vegetation had upon the air. When the question of the inflammability of teak was raised, his thoughts reverted to

the first stockade he saw burnt on the banks of the Irrawadi in the last Burmese war. It was a quarter of a mile in length, made of well-seasoned logs of teak, probably a foot square, and he remembered being much impressed at the time with astonishment that a stockade would have burnt like a bonfire as that did; for the next morning there was nothing but a few blackened sticks remaining. He was not aware before that teak grew in parts of India and Burmah which seemed to differ so much from each other. He should like to know at what elevation it grew in Burmah and Pegu, and how it compared with that grown on the Western Ghâts at a height of 3,000 ft. He should also like to know Colonel Beddome's opinion as to the probability of teak growing in Bengal itself. Years ago, he and others had suggested the growth of mahogany in Bengal, where, he believed, it might be grown to any extent; but it was very hard to make people realise the importance of these things, or to carry out a scheme of the kind after they had realised it. The whole subject of forestry was of the utmost importance to the welfare of the country, both for sanitary reasons and as regulating the temperature and modifying the amount and distribution of rainfall.

Colonel BEDDOME said teak would not grow well beyond 20° north latitude; it would not grow out of the influence of the south-western monsoon. In the plains of Bengal there was not sufficient rainfall. In Burmah he had seen it very near the sea level, at an elevation of 600 ft. or 800 ft., but there was a very heavy rainfall; he should say 150 inches of rain a year was necessary for the growth of teak. Mahogany was largely planted, and promised to be a splendid tree for India; it grew very well in Calcutta, and he believed it was the tree of the future. The difficulty had been to get seed, which had to be brought from Honduras or Jamaica, and did not survive the journey if exposed to frost. An immense number were planted in South India, and Mr. Macdonald had also planted them in North Canara.

The CHAIRMAN, in proposing a vote of thanks to Mr. Simmonds for his very interesting paper, said he had been asked to say a few words on the subject of forest conservancy, and its great importance as affecting the timber trade with India and the East, and the future supply of marketable timbers in Europe. At the late Forestry Exhibition in Edinburgh, at which he had the honour of representing India, very fine collections were sent by the Governments of India, Madras, and Bombay, and great interest was created amongst timber merchants and others, for he had many inquiries made with regard to the qualities of the different kinds and the prices. The Bombay and Burmah Trading Corporation, the Maharajah of Johore, and the Government of Siam, also sent fine specimens of woods, including teak. Teak and rosewood, or blackwood, had been known in Europe for many years, though he had no idea of imports of teak being so great as Mr. Simmonds stated; but there were a great many other Indian woods which he was sure only required to be known to be thoroughly appreciated, and he had no doubt a trade might be developed with India, Burmah, Siam, Johore, Borneo, and other Eastern countries. At the close of the Edinburgh Exhibition, a local cabinet-maker and builder purchased a number of pieces of almost unknown woods, at the price of 5s. per cubic foot all round, which was a clear proof that if woods of that description were put on the market a remunerative price could be obtained. Amongst these woods were *Pterocarpus indicus*, *Shorea obtusa*, *Cedrela toona*, *Pentace Burmanica*, *Pterocarpus marsupium*, *Lagerströmia flos reginæ*, *Shorea obtusa*, *Shorea Siamensis*, *Fagræa fragrans*, *Terminalia glabra*, *Hopea odorata*, *Sandoricum indicum*, *Acacia arabica*. India was doing more than any country in the world for the preservation of its forests, for at the present moment, nearly £200,000 per annum were expended in guarding the interests of the State and of the people who, only a quarter of a century ago, were in the habit of felling large tracts of forest for rude cultivation, utterly heedless of the future supplies of timber and fuel, and entirely ignorant of the results on the climate. With regard to the work of this department, he could not do better than refer to the Society of Arts *Journal* for March, 1882, in which a short history of its operations appeared, by Sir George Birdwood. He showed how the first really practical and sustained effort towards doing something to the forests began in 1847, when General Frederick Cotton, of the Madras engineers, urged on the Government the desirability of taking its forests into its own hands, and, at his recommendation, an officer was specially entrusted with carrying out his proposals. He (the Chairman) happened to be the officer whom General Cotton selected, having seen something of forestry on the Continent of Europe. Acting under his instructions and advice, and aided by the civil officers of the district, Mr. Thomas and Sir William Robinson, he was fortunate enough, in six or seven years, to bring General Cotton's experiment to what the Court of Directors were pleased to call a successful issue. By that time, a small tract of forest was put into systematic working order, some adjoining forests were leased, saplings protected from fires, roads and timber slips were made, and the foundation was thus laid for a regular forest department, which, about 1857, the Court of Directors sanctioned, to which Colonel Beddome had just alluded. After those seven years of pioneering work he suffered so much from jungle fever that he was obliged to withdraw from forest life, and the creation and organisation of a Department fell into the able hands of Dr. Cleghorn and Dr. Brandis, who worked it out in the Bengal Presidency, and brought it to its present position, costing the Government £200,000 a year, but doing a most magnificent work all over India and British Burmah. The forests were now well looked after, and produced a clear annual

revenue of £400,000 after paying all expenses. General Cotton had always generously given him the credit of having successfully started practical forestry in India; but he could only say that, whatever his part might have been, there was no doubt that if General Cotton had not given the Madras Government the timely advice he had, and induced them to go warmly into the matter, conservancy might have been deferred for many years, and then we might have had to say "too late." Forest conservancy was a boon to the whole country; at the same time, it was now carried on under recent Forest Acts, which required very careful handling. The revenue should be looked upon as quite a secondary consideration; preservation was the first thing, and the greatest possible care should be taken to secure to the people ample supplies of fuel, wood for implements, bamboos, &c., according to old custom, otherwise there would be impatience of restriction, disregard of the law, increase of petty crime, forest mischief, and perhaps disaffection to the Government. This was the opinion of the Duke of Buckingham when he was Governor of Madras, who, as a practical forester himself, took a lively interest in all forest matters. The Madras Presidency was certainly first in respect to caring for its forests, and the same might be said in the matter of teak plantations. Mr. Connolly began in 1844, and specimens were shown at the Edinburgh Exhibition from the Nilambur plantation comprising 36 sections from trees planted in consecutive years from 1844 to 1876; the largest measuring 8 ft. 4 in. in circumference, taken from a tree 103 ft. in height, and being only thirty-seven years old. A very remarkable feature of this plantation grown teak is the almost total absence of heart shake, which is so common to forest grown teak, and which is the natural split running up the centre. With regard to girdling, he did not profess to know much about it, but when in charge of the experiments in 1851, he was sent over to Burmah by the Madras Government, to see how they managed the forests there; and for some seasons afterwards he had trees girdled, but the practice was stopped because the Malabar foresters, who were exceedingly clever axemen, declared that when a girdled and dead tree was felled it came down with a greater crash than the green tree, and the consequence was that the natural heartshake was very much increased, and sent splits all through the wood.

The vote of thanks having been carried unanimously,

Mr. Simmonds said he was very pleased to find that this paper had elicited so interesting a discussion. He did not profess to have any practical knowledge of the subject himself; but having been a juror at various international exhibitions, where he had to deal with timber, it struck him that this was a subject which might be advantageously brought before the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, February 24, 1885; Hyde Clarke in the chair.

The paper read was—

THE AURIFEROUS REGIONS IN THE NORTH-WESTERN PART OF SPAIN.

By William Sowerby, F.G.S., M.Inst.C.E.

Introductory Remarks.—In order the more fully and completely to make manifest the importance and value of these mineral deposits, it is first necessary to describe the topography and extent of the country, and to indicate its lithological characteristics.

The want of full information of this kind has too often been the cause of failure in the practical and profitable working, not only of gold mines but of every other sort of mining adventure.

In the absence of any complete official Government surveys, which require years for preparation, the following description must only be considered as an approximate and general outline of these vast auriferous regions; it is, however, hoped that the paper will answer some practical purpose for preliminary investigation, and that it will help on further explorations.

In order to lay down working plans for developing the mines, accurate and carefully prepared details are essentially necessary to make reliable estimates. Sufficient has, nevertheless, been done to enable any expert of long experience on such works to form a judgment, and to give a very decided opinion upon the promise and value of the mines.

In this paper, the various salient points will be indicated, and the most likely places to commence working; also the probable results.

Situation of the Mines.—These auriferous deposits are found in an extensive succession of undulating hills. Mountains, valleys, and plains, stretching from the southern slopes of the western part of the Pyrenees, locally called the Cantabrian, Asturian, and Santillanos Cordilleras, in the provinces of Leon, Galicia, and Asturias, in the north, and extending to the confines of the province of Valladolid and of Portugal in the south, or from North Lat. 42° 10′ to Lat. 42° 60′, equal to 50 miles, and from the Rio Esla (a tributary of the Douro) on the east to the Rio Miñho (or Miño) on the west; or, say, from Long. (West) 5° 40′ to Long. 7° 20′, equal to 100 miles, or a region consti-

tuting from 4,000 to 5,000 (geographical) square miles.

It is not to be supposed, or assumed, that the whole of this vast region is equally auriferous; but there are so many well-known points where gold has been found, that it is quite justifiable to consider the extent of country above stated to be more or less auriferous throughout, and very many parts of it to be exceedingly rich.

Topographical and Lithological Description of the Gold Region.—On leaving the railway station at Palencia (on the line from Madrid to Santander), where the surrounding hills are of limestone and limestone shales (one conical-shaped hill surmonnted by a monastery being conspicuous close to the station), and travelling in a north-westerly direction towards Leon, the country is a wide, undulating plain, on which enormously rich crops of grain are grown; this plain is alluvial, and gives the impression that it has been, at no distant geological period, an inland lake or sea.

This peculiar characteristic of the country continues up to and beyond the River Esla, and on to the old city of Leon. Gold has been washed out of the Rio Bomesga, which passes through the city of Leon; the Bomesga is a tributary of the Esla and Douro; the distance from Palencia is about seventy geographical miles.

Beyond Leon, continuing westward towards Astorga, a range of low hills intervenes, and then there is another series of undulating low hills (chiefly schistose and alluvial), which occur for a distance of forty geographical miles, until a very high range is reached at Branuelas. This range runs nearly north and south; the height is about 3,500 to 4,000 feet above the sea, as measured by barometer. This ridge is the water-shed, and divides the drainage area of the Rio Douro from that of the Rio Miñho, with their numerous tributaries. The tributaries of the Rio Miñho are the Rio Boeza, the Rio Sil, the Burbea, the Cabrera, and the Quiroga; the Minho empties itself into the sea at La Guardad. The drainage area of the Rio Douro also includes many tributaries, namely, the Esla, the Duerna, the Eria, &c.; it empties itself into the sea at Oporto.

The distance from Leon to the top of this primary dividing ridge is about fifty geographical miles, and within this area are the rich alluvial beds of Astorga. On the highest points near to Branuelas, there are extensive and deep beds of gravel, but much of these is, however, unworkable, owing to the elevation above all neighbouring streams.

This mountain range is partly dioritic, and partly granitic, these primary rocks having obtruded through and disturbed the schistose rocks; beyond this ridge the valley of the Rio Boeza and its tributaries begins. This river is a large one, and it finally joins the Rio Sil at Ponferrada. Beyond the ancient city of Ponferrada are Villafranca, Las Medulas, El Barco, Valdeorras (or the Valley of Gold), Domingo Flores, Montefurrado, San Clodio, and Quiroga; this embraces a distance of about seventy geographical miles from east to west.

Besides the Rio Sil and Boeza, there are the Burbea, the Cabrera, the Quiroga, and many other minor mountain streams, which are tributaries of the Sil and the Miñho. The whole of this district, embracing the Boeza, the Sil, the Burbia, the Cabrera, and the Quiroga, is very hilly, rising to a considerable elevation; in some parts it is a mountainous country, rising to a height of from 3,500 to 4,000 feet and upwards. In many parts the ground is much broken and disrupted, especially around Branuelas, Ponferrada, Domingo Flores, and Las Medulas, which latter place lies between the Sil and the Cabrera; this is where some of the richest and most extensive gold deposits are found, and again in the region from El Barco, Montefurrado, and San Clodio, between which points the granitic rocks once more occur; there, also, the schistose hills are more abrupt. Wherever the mountains are high, the valley of the Sil becomes narrower, and the adjacent rocks more precipitous.

Communications.—Access to and through this region is now easily obtained by means of excellent "royal roads," which traverse the whole country from Palencia, and other places, *viâ* Leon, Ponferrada, Domingo Flores, Puente Nuévé, El Barco, and Rua, on to Orense, and so on to the west coast of Spain at Vigo, and of Portugal at Oporto. There is also a road, *viâ* Ponferrada and Villafranca, to Coruña. These roads pass through the whole length of the auriferous territory, and are well-maintained high post roads; but a line of railway has been recently opened right through the country to the ports on the western and the northern coasts, and this railway intersects the mineral deposits in the most complete manner possible. Where the line cuts through beds of gravel, it has been thrown up as embankments, or used as ballast; veins of

quartz have been exposed and intersected by tunnels, &c., and parapet walls have been built of the gold-bearing rocks, the gravel and rocks being highly auriferous.

Lakes.—One of the peculiarities of the country is the existence of a number of natural lakes. These lakes or "tarns" are like many similar mountain lakes in England, Scotland, Wales, and India. They are situate at a very high elevation, mostly at the base of some prominent mountain peak, and near the sources of the mountain streams, as the Lago de Baña, at the head of the Rio Cabrera, also the lake at Filiel, near the Astorga gold fields. These lakes are generally fed to a large extent by springs of water rising in the mountains.

The Geological Formation of the Country.—In the absence of any regular survey, this can be only very imperfectly described. Commencing at Palencia, the vast alluvial area has been already partly delineated at the outset of the paper. These plains continue, as already stated, up to the mountain range which forms the watershed of the Douro and its tributaries on the one side, and of the Miñho and its affluents on the other.

The range of hills westward of Leon is chiefly composed of schistose rocks of the Silurian type. Wherever the bed rock is exposed up to and beyond Astorga, and onward towards the high range at Branuelas, this bed rock is schistose.

On the flanks or slopes of these schistose rocks lie the alluvial beds of gravel, in which are found traces and "flakes" or "pepetas" of gold more or less rich; at some parts the gravel is very rich in gold. This is particularly the case about twelve miles to the south of Astorga, in a broad valley through which flows the Rio Duerna, a tributary of the Esla and Douro.

In the schistose rocks there are many veins of quartz which are known, by testing, to be auriferous, but visible gold is seldom seen in the quartz, though the veins at the outcrop look very promising, and yield gold on assay to the extent of about 2 dwts. per ton.

In the high dividing range of the mountains, trap or dioritic rocks protrude, causing great dislocation and distortion, and lower down are found granitic rocks of a grey colour which, in some places, have a stratified appearance like gneiss. Beyond this range the hills slope very rapidly towards the River Boeza, and the Rio Sil, at Ponferrada. Immediately after passing the summit level of 3,500 ft., the schistose rocks become prominent, and on the flanks of those schists, and in the valleys, rest the alluvial gravels as before described. In these schistose rocks, besides small veins, there are many large lodes, and on the top of these lodes also above the gravel beds, there are masses of hard conglomerate; these lodes and conglomerates yield gold, and they appear to have been extensively worked in numerous places, as shown by old galleries. The gravel beds are all composed of detritus from the neighbouring hills, namely, quartz in more or less quantity, boulders mostly of quartz and schist with some trap, and also magnetic iron ore; and wherever the quartz and iron are most abundant there the gravel is invariably richest in gold—in fact, without the quartz and magnetic iron, there is no appreciable quantity of gold. At and near the confluence of the various streams, the gravel beds are exceptionally rich and well defined—this is especially the case where the Boeza joins the Sil near to Ponferrada; these deposits occur just beyond the point where the granitic rocks have penetrated the schists. The washings from these gravel beds gave 2 dwts. of gold per ton of stuff, and were even richer near the bed rocks.

The city of Ponferrada is a very ancient town, it is situate on high ground, where there the Boeza and Sil join each other, and it may be called the very centre of the great gold region; it is surrounded by moderately high hills, and the gold basin can be easily traced by the ferruginous red colour of the ground. The basin continues not only in a directly westward course along the valley of the Sil, and in the adjacent plains, but also in a north and north-westerly direction beyond Villafranca and the Rio Burbia, where extensive deposits are known to exist, and have been extensively worked; around Ponferrada the old workings have been considerable, and at this point some ancient Roman cupolas for smelting the gold have been found.

Following the valley of the Rio Sil westward, immediately after leaving Ponferrada, there is an extensive plain, which, on being tested, invariably yielded gold in each "batea" or pan; this plain is partly under poor cultivation, being nothing but gravel and boulders with a little soil; the high road and the railway both cross this plain, the road is carried over the river by a costly new iron bridge. Beyond this bridge, a few miles along the high road, are the ruins of an ancient castle, said to have been built by the Romans during the period of their occupation, and restored by the Knights Templars of more recent times.

The geology of the hills around is the invariable schistose wherever the bed rock is visible, with the same alluvial deposits on the banks of the river, and on the flanks of the hills; some of these alluvial beds rise up in abrupt "scars" by the side of the River Sil; and wherever small streams join the main river, these alluvials appear to have been worked.

The country along the valley continues to be of the same schistose and alluvial character throughout, until the Lake of Carucedo is reached; the high road passes this lake within fifty yards or less. It is believed to be a natural lake, and it is about 300 feet above the Rio Sil, but it is separated from that river by a low mountain range; behind and above this lake there appears to have been, formerly, other lakes up the valley, towards Borranes, these latter have, however, dried up and been drained, and partly cultivated and reclaimed.

Beyond this lake going westward, there is an abrupt change in the geological formation; large hills of mountain limestone rise up on the side of the Rio Sil, and to the south of the lake there is a very extensive auriferous gravel bed, of about a mile and a-half wide, and higher up the hills, in the same direction, are the ancient mines of Las Medulas, which are of gravel, lying on the flanks of the schistose rocks as usual. This sub-range rises up to about 1,700 feet above Lake Carucedo, and about 2,000 feet above the Rio Sil.

The Las Medulas gravel deposits are conspicuous from the high road at Carucedo, there being many lofty and fantastic peaks and pinnacles rising to an elevation above the adjacent ground of from 400 feet to 850 feet, with an unbroken face or "scar," which has been made artificially by the denudation works of the old miners, for the purpose of extracting the gold from the gravel.

Leaving Las Medulas, and passing through the limestone range with its abrupt peaks, and travelling westward, the village of Salas is passed; this village is on the banks of the Sil river. Here the schistose rocks again appear in the red gravelly alluvials, on the hill sides, and at their base; but they do not rise to the same elevation as those of Las Medulas, which latter seem to be the culminating point of an immense ancient geological basin, or river-bed; both the depth of the gravel, and the extent of the deposit being the greatest at that point, which has been elevated at a remote geological epoch by some powerful upheaving influence, to its present conspicuous and remarkably singular position; these deposits will be further discussed, hereafter, in this paper.

Continuing down the valley of the Sil (along the left bank of which is the royal high road, while on the opposite bank is the new line of railway), in many parts of the river there are dry patches of auriferous sand and river boulders, and wherever the bed rocks are seen, they enclose numerous veins and lodes of auriferous quartz, which have been penetrated by galleries and worked at many points.

At Domingo Flores the River Cabrera joins the Rio Sil. The rocks continue to be the same, but at this point, and more particularly on a hill just opposite the village, at a place called Querano, the gravel assumes the more hard character of conglomerate. The boulders, pebbles, gravel, sand, &c., are cemented together with a hard ferruginous kind of cement, composed chiefly of a little clay, with fine grains of quartz and sufficient iron to tinge the stuff a deep red colour, and the whole is thus formed into a solid hard mass, but in other respects the bed resembles the ordinary gravel beds, only redder and more hard; the hardness appears to be due to exposure. Extensive deposits of this conglomerate are found again and again all the way along the valleys of the Rio Sil and its tributaries, as far as Montefurrado and San Clodio; in some places huge blocks, many tons in weight. are lying on the surface; at other places there are extensive beds exposed by denudation, either in the rivers or on the sides of the hills. The large blocks are, however, found to be overlying the schistose rocks, and sometimes, as at El Basco, they are above the gravel beds on the same hill side.

The granitic and trap rocks appear to form the chief rocks of all the higher ranges, and the Rio Sil and the Boeza cut through a range of these rocks above Ponferrada; and again at a short distance beyond Rua on the road to Orense, where the valley becomes very narrow and the hills on each side very precipitous, the granite rocks are found cropping out. Beyond this point, up to Montefurrado, the schistose and clay slate rocks again abut on the river, and there are very many veins and lodes of quartz visible in these schists. The schistose rocks nearly always lie at a very abrupt inclination with the horizontal plane, and they usually dip with an angle of 75° to 80°, and the strike is nearly E. and W.

The River Sil takes its rise in the mountain regions to the north, and its course is, like all

mountain streams, very circuitous and mostly very rapid, having a slope or gradient of from 50 to 60 feet per mile, and in some parts 150 feet, or from 1 to 3 per cent.; while its tributaries, such as the Boeza, Burbia, Cabrera, Quiroga, &c., have a still greater gradient, in some parts of its course, as below Ponferrada, the valley and river widen out to a great breadth; this occurs again, only in a less marked degree, at Salas and Domingo Flores, also at El Barco and Rua, as well as at Montefurrado and San Clodio; while at other places, viz., near Carucedo, Puente Nuévé, and beyond Rua, the valley is narrow, and the sides of the river are somewhat precipitous and abrupt; generally, however, the river is deep below its banks, except at the places above mentioned.

At various parts along the course of the different streams, the bends give a somewhat horse-shoe shape; this is the case near to Carucedo, the village itself is, however, two miles away from the Sil, in a valley running parallel to that river, in which valley the lake before mentioned is situated.

These bends have been taken advantage of for laying dry the beds of the rivers at certain seasons, and washing the gold out of the sand and gravel. There are many points too, along the course of the river's bed, which are periodically flooded, and which, when dry, are washed for the gold brought down out of the hill sides, and arrested at its course; some of the pools also contain much gold left by the passing floods.

The geology of this extensive region, which contains gold, resembles in most particulars similar gold regions in other parts of the world, especially those in California and Columbia; they are very extensive in point of area, but the gravel beds, perhaps, surpass in depth and height anything of the kind in the known world. Eight hundred and fifty feet of gravel (as it is at Las Medulas) is, it is believed, in thickness beyond any other known similar deposit of gold gravel in any other part of the world.

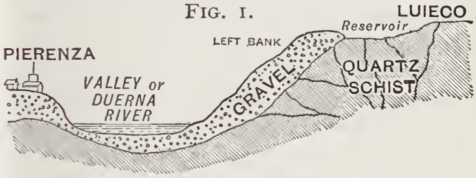
The Mines.—Commencing from the eastward, the first group are those in the district near to Astorga; which is a very ancient city, and it is built on an elevated bed of auriferous gravel; and travelling southward from that city the country is one continued series of undulating low hills and valleys composed of schistose rocks, with gravel beds resting on the slopes of the hills and in the valleys, and with quartz veins running through the schists, the surface being covered with boulders and fragments of quartz. The gravel is composed of smaller pieces of quartz, schist, and ironstone, and this continues until the River Duerna is reached, at a distance of about twelve miles from Astorga.

The banks of the Duerna rise to a height of from 100 to 150 feet on the left side (the river flowing eastwards), and these banks are composed of a reddish yellow gravel with boulders and fragments of quartz, and a matrix of yellow clay; this gravel gives visible gold on being washed, every pan of stuff that was washed gave one, two, or more small "pepetas" or "colours" of gold; this is at and near the village of Pierenza.

Higher, upon the left bank of the River Duerna, near the village of Luiego, there are the remains of an extensive ancient reservoir for water, and immediately below that point there have been very large washings of the hill sides. The bed rock is, in some places, very near the surface, and there is, consequently, but a thin covering of gravel; at other points, however, the gravel is of great depth and thickness, as shown very clearly by the old workings, which have but very partially cleared away the immense deposit.

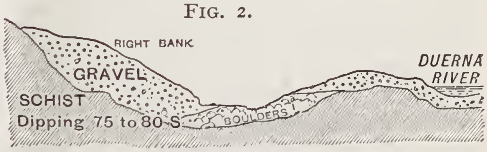
The following sketch represents the appearance of one of these huge banks from the opposite side of the river:—

FIG. 1.



The thicker beds of red gravel recede some little distance from the present course of the stream; the intervening space being gravel and large boulders of quartzite, &c.; the gravel beds rise to an elevation of from 80 to 150 feet, and upwards thus—

FIG. 2.



Along the whole course of these gravel beds, from the village of Pierenza, for a distance of several kilometres (probably twelve miles), there are found the remains of ancient workings to an enormous extent, as shown by the

numerous waterways (sluices) leading from the gravel beds to the river, which occur at intervals of every 100 yards or less; and on following up the courses of the small streams coming from the hills on the south, there are the remains of extensive hydraulic washings, with canals, reservoirs, and all the needful works for extracting gold on a very large scale, while the heaps of boulders show that thousands of tons have been removed and washed.

The water was partially brought from a small mountain lake (still in existence), about three kilometres (two miles) from the mines, and the remains of the old canals still exist. Great as have been the workings of the ancient miners, they have done but little to exhaust the immense deposits of gravel which apparently extended at this place for a distance of twenty-five to thirty miles in length, and about two or three miles or more in width; this is of course a very general estimate of the extent of the auriferous ground, but there can be no doubt that sufficient workable mineral is still available for works on the largest scale for many years to come, in fact a generation or two will not exhaust the deposits. The extent of the works will, however, have to be limited by the supply of water.

The small tributaries of the Duerna and the canal appeared, when visited, to yield about fifteen cubic feet of water per second, that is about twenty feet wide, one foot deep, and flowing at the rate of about nine inches per second; this would be equal to about 400 to 500 miners' inches (assuming 1,232 gallons or 189 cubic feet to be equal to 100 miners' inches), but the larger river, Duerna, would be equal, perhaps, to 1,000 miners' inches if the whole of the stream could be made available, and with such a supply, 60,000 to 100,000 tons could be washed per month; a portion of the water only is now used for irrigating purposes in the fields on the low grounds. This need not, however, be interfered with; indeed the supply of water might be increased for such purpose if the works were carefully laid out, and the double object kept in view.

The assays which have been made of these gravel beds need not be accepted as strictly accurate data upon which to base any calculations. These, however, have given as much as 10 grammes of gold per cubic metre, and an assay gave as much as 9 dwts. per cubic metre. These assays were made after the rough boulders had been extracted, and these stones would form about 75 per cent., in bulk, of the whole gravel bed; so that a true proportion would be from $2\frac{1}{2}$ grammes to $2\frac{1}{4}$ dwts. (English) per cubic metre, or say about one gramme per ton, the gramme being worth 2s. 6d., so that if the cost of reduction, sluicing, &c., be 6d. per ton (which is an excessive rate), the net yield per ton would be 2s., which, on 100,000 tons a month, would be £10,000. This is a question which must, however, be much more carefully discussed when the exact works are finally determined upon, and fuller information as to the water supply, and the productiveness of the gravel beds has been more accurately as-ascertained. There can, however, be no doubt that the deposits on and near the Duerna river offer most favourable facilities for the commencement of the works of washing on a moderate scale, and of extending the same when they are found to yield profitable results.

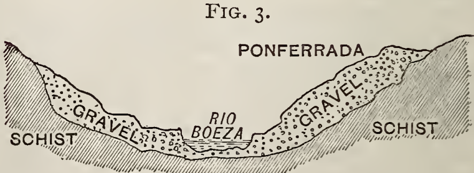
There are three rivers in this locality, viz., the Duerna, the Orvigo, and the Eria, which are tributaries of the Esla and Douro, and rise under Mont Teleno, on the eastern side of the same mountain range, in which the River Cabrera, a tributary of the River Sil, rises.

These rivers, the Duerna, Orvigo, and Eria, drain an area of from 500 to 600 square miles, and there is a large lake in the district which is also available. Should the water from these rivers not be sufficient, then it is possible to increase the supply by large reservoirs as is done in America and elsewhere, but the probability is that there would be sufficient water in the Duerna itself to meet all requirements.

Besides these gravel deposits on the Duerna river, there are many other places in the Astorga district where auriferous beds are found, being conspicuous by their red colour and peculiar appearance at a distance all round the country, many of them having been largely worked.

The Boeza Valley.—Along the whole of this valley there is an immense extent of auriferous gravel beds, especially near and around Bembebre. The beds commence immediately

Fig. 3.



beyond the ridge at Branuelas, and in many places there are old workings, but the richest place is near the junction of the Boeza with the Sil. The valley here is broad, and the beds

well exposed, and they are of considerable thickness. The foregoing sketch (Fig. 3, p. 364) is a representation of this part of the valley.

The Las Medulas.—The group of mines at and around Las Medulas are of great extent, and they have been worked on a stupendous scale in ancient times, as is clearly shown by the *debris* from the washings, which covers many thousands of acres.

These mines are first noticeable from the high road at and near the village of Carucedo, the red gravel peaks rising up on the south to a great height (perhaps 1,700 feet), and being conspicuous because of their peculiar and fantastical pyramids and pinnacles, which are visible at a great distance.

The exact extent which these gravel beds occupy in length and width cannot be very well defined. They are found by the banks of the Boeza, the Sil, and on the Burbia, and again on the Cabrera, and they extend from beyond Ponferrada on the east, up to and beyond Domingo Flores on the west, with an area of about 1,250 square miles, being twenty-five miles from north to south, and fifty miles from east to west.

The true character of the deposits are easily and clearly ascertained, not only at the various points where they have been upheaved and exposed, or laid bare by the action of denudation, in the Boeza, the Sil, the Burbia, the Cabrera, and their tributaries and branches, but also from the fact that they have been worked on such an extensive scale that there can be no doubt as to their immense area, nor any difficulty in ascertaining their true character and value. The deposits in the Medulas district differ but little from those at Astorga, except, perhaps, from the works having been on a more stupendous scale—more gigantic in quantity and more disturbed by upheavals, while, from the appearance of the gravel, and its general character, the quality does not materially differ.

The Bed Rock, or base rock, of schist, is of a bluish grey colour, and not very compact, but loose and friable, especially where it is exposed and weathered. These schistose rocks form the series of hills which run in a southerly direction from the main sierra, or mountain range of the Pyrenees in Galicia and Asturias, and the country takes the form of a complete basin, extending from San Clodio and Quiroga, Montefurrado and El Burco, on the west, to Ponferrada and Branuelas on the east, a distance of about sixty geographical miles, by about forty miles wide, comprising in all about square miles. This area includes several subsidiary basins, which further explorations will more clearly define.

Low down in the valleys, especially near the Sil, Boeza, &c., are found beds where the gravel is coarse, and comparatively clean; further up the gravel becomes less coarse, and more red in colour, and a little clayey, or argillaceous; then, still further up, these beds become still more clayey, and less free, as at Las Medulas, which is the highest point, and there the strata is intersected by bands of bluish white clay, which runs in regular seams, alternating with small gravel beds of schist, quartz pebbles, and ironstone.

The entire thickness of these gravel beds from the lowest point near the Boeza and Sil to the highest point at Las Medulas or Branuelas cannot be far short of 2,000 ft.; this, it must be remembered, is not in one continuous stratum, but a succession of steps, each differing slightly in character, but all containing alluvial gold; while in the underlying schistose rocks are numerous veins or lodes of auriferous quartz, which are evidently the parent source of the golden gravel covering so extensive an area of country; and there can be but little doubt that in the higher regions of Galicia, Asturias, and Leon, there are other gold-bearing quartz rocks which, in time, will become known and worked—in fact, the existence of these gold rocks is already known, and some of them, like other gold reefs, have been worked in ancient times. In the mountains to the north of San Clodia, where the Quiroga river rises, there is a reef of quartz which traverses the country for many miles in an east and westerly direction, and which contains gold, silver, and tellurium, simular to the rich tellurides in Colarada.

The working of the mines at Las Medulas appears to have been on as vast a scale as are similar works in modern times, through the instrumentality of water brought over the mountains at the source of the Cabrera; the water was brought on to the face of the gravel beds for a distance of 50 miles, and there collected in reservoirs, then allowed to flow over a vertical fall of from 400 to 800 feet in height. The waters were evidently used in the first instance for denuding the lower hills near to Carucedo down to the bed rock of schist, and the work gradually receded backwards until the immense quarry hole of Las Medulas was excavated, having a vertical face of 800 feet from the base to the summit, and

there are many pinnacles of gravel left standing isolated in a huge amphitheatre, because they could not be cut away, as they had no hydrants or monitors in those days. The exact mode of working has not, however, been explained, and the secret of recovering the gold is said to be a lost art, though the process is fully described by Pliny; a great number of slaves or prisoners of war were employed (some 60,000 according to Pliny). They were occupied in removing and piling up the boulders and *debris* which are now to be seen scattered over the country for many miles, covering thousands of acres. The water, after being used for breaking down the hills, flowed through several gorges, and into some small lakes or settling pools, which are still in existence, and then found its way to the large lake at Carucedo, and so on to the Rio Sil down a steep gorge between high banks of gravel and schistose rocks.

The old canals are still traceable, and portions of them are in a complete state of preservation, so much so that they might be again utilised for the same purpose. The canal appears to have been divided into six or seven minor channels as it approached the Las Medulas, where it was allowed to flow over the gravel bank, though the breaking down of the bank was also probably partially effected by manual labour.

That the works were on a vast scale is sufficiently clear, and that millions of tons were broken down and washed is also very certain; but there is nothing like an exhaustion of the deposits; the quantity remaining will last for generations.

The gravel of Las Medulas invariably yielded colours of gold on being washed; this continued from the very top to the point where the water flows down the gorge below Carucedo, and amongst the gravel occasionally are found small nuggets of an ounce in weight, picked up by the shepherds and labourers. This has occurred both at Las Medulas and in several other localities, but the largest grains of gold have been found in the gravel on the Boeza in the Cabrera, the Sil at El Bureo, and Quiroga. Usually, however, the gold is fine flower gold, and the finer it is the more plentiful it appears to be, but also the more difficult to secure. The water of the River Sil is very plentiful, probably 10,000 miners' inches; there are seasons, however, when the rivers are unusually low, as in most countries, but, as a rule, they never become very low or dry, as they are fed by many mountain rivulets and springs, the snow frequently remaining on the tops of the mountains for months.

At Domingo Flores the River Cabrera joins the River Sil, and near to that place there are numerous old galleries driven into the gravel and conglomerate beds, more especially at a point where the schist rocks and limestone formation come in contact where the gallery is of great extent.

Along the whole course of the Cabrera itself the gravel has been always famous for its gold, and it has been obtained by simply washing the stuff taken from the river's bed in an ordinary "batea," or wooden bowl of conical shape, which will hold from twelve to twenty pounds of earth and sand, the result being invariably several "pepetas" of gold; and a day's washing will give from five to ten pesetas (from 4s. to 8s.), and seldom less than three pesetas, or 2s. 6d.

The conglomerate, which is very abundant in the neighbourhood of Domingo Flores, is said to be rich in gold and silver, varying from ½ oz. to 2½ oz. per ton of stuff. It also contains many other metals, such as tellurium Iridium, silver, platina, &c., &c.; but the stuff is refractory, and will require careful and special treatment in its reduction. There is, however, ample water-power in the neighbourhood for putting up any kind of crushing mills, &c., for treating and smelting the mineral.

Beyond Domingo Flores the Valley of the Sil widens out into what is called the Valde-Orras, and here commences those rich river washings which have given the name to the district. Here the old Roman or other ancient workings have been on a most extensive scale, as indicated by the heaps of boulders piled up for many miles. The washings have, however, been mostly on low ground, close to the river, every reach, or horseshoe shaped bend, having been most skilfully laid bare and washed clean.

Up to the present time, after every flood in the river, there is a fresh crop of gold in the sand, which is surcharged with grains of the precious metal. The natives annually take a spell at the gold washings, but only during a few weeks each year, such being the only time they can spare from their other occupations in the fields, which, being less precarious, are therefore more profitable. Lately, these annual washings have been less, owing to the railway company affording regular employment during the construction of the works.

At El Barco the auriferous gravel beds

reach down and across the River Sil. The town is built upon gold gravel, aud these beds go up the hill sides to the village of Castro, the beds being forty to fifty feet in thickness; at the lower part of the valley, there are, however, four to five feet of top-soil, which is partly cultivated, and the hill slopes are covered with vines; wherever the gravel was tested it yielded very good colours of gold. One small stream, which flows through El Barco, is known to yield large quantities of gold, and is annually washed, like the Cabrera, and other streams, with profitable results.

Beyond El Barco, towards Rua, the gravel beds are continuous, from the river's bed to far up the hill-sides, to where the bed rock crops up, and beyond that place (Rua) the valley narrows, and the granite appears running right across the country. These granites continue for some distance towards Montefurrado, where the schists again occur, with the usual gravel-beds, which have been partially worked.

At Montefurrado there is an extraordinary work of the old miners. The ancient bed of the River Sil passed round a long, rocky promontory of schist, shaped like a neat's tongue, the river's bed describing an elongated, horseshoe shape. At the narrowest point a tunnel has been cut through the hill, and by this means a long stretch of the river was laid bare and washed for gold. The scour of the river over the soft schist has gradually deepened it, until it is ten to fifteen feet in depth, and the stream now flows at a level considerably below its former course, but it occasionally rises, during floods and passes, along the old waterway, and the sand when dry is again washed for gold with good results, but the gold is extremely fine and flowery, showing that it has travelled a long distance.

Beyond Montefurrado, towards Lugo and Corunna, down the Sil Valley, the same schistose formation exists until the river joins the main stream, the Miñho, and at several points, along the course of the stream, there are a succession of gravel deposits and some old workings. This is especially the case at the small tributary called the Quiroga, a stream of about the same size and character as the Cabrera; this river joins the Sil near San Clodio, a station on the railway. At this place the gravel beds are very deep and rich (60 to 120 feet), giving visible coarse gold in every pan washed.

There are, at this place, very extensive remains of old workings on both sides of the river with galleries and watercourses, and there is still an immense field of virgin gravel remaining to be worked with ample water either from the Rio Sil or the Quiroga.

To attempt to estimate the value of these enormous gold deposits would be vain, their extent is so vast while their richness is unquestionable.

The Romans are said to have obtained 20,000 lbs. weight of gold annually from these mines (Pliny); this would be nearly one million sterling, and this was continued for about 300 years during the Roman occupation; to accomplish this they had 60,000 slaves and prisoners of war employed, and the country was, doubtless, then much of it in a state of nature, with dense forests and a correspondingly copious rainfall. But these old miners had none of our modern appliances. It would then be indeed strange if in modern times, with the best appliances possible, similar or even greater results could not be obtained; for there are the vast deposits still untouched, notwithstanding the immense amount of work that has been done, in addition to the masses of conglomerate and gold quartz which have also been but very partially worked. There is also abundance of water flowing through the valleys of this extraordinary country, and the forests, though not dense, as in the time of the Romans, are still ample for all mining purposes, in fact, some of the oak forests are of very great extent and value.

Besides the valleys of the Rio Sil, Boeza, and other streams, which have been more fully described in this paper, there are other streams on the north of the Pyrenees, such as the Navia, &c., where gold exists, and where old washings are found. There are also many other minerals, such as coal, iron, galena, copper, tin, antimony, and cobalt, found in the district; while in the rivers to the south, in Portugal, gold is known to exist; but much time must be required before all these can be known and explored.

To commence works anew will require the utmost care, caution, and skill, but if once success should be obtained and assured with a moderate outlay of capital, then confidence will be established for developing the mines on as large a scale as possible, and it should be remembered that these valuable gold mines are not in the centre of tropical Africa, or India, or thousands of miles distant, as in

Columbia, California, or Australia, but only three days distant from London, and two days from Paris, a great advantage where good management has to be considered, on which so much of the success of all mining depends.

DISCUSSION.

Mr. Moon asked if there were any probability of litigation in Spain, such as had recently taken place in California, with the result that, in 1883, there was a reduction of three million dollars in the value of gold produced compared with the production in 1882. Only that evening he saw in the paper that in one State there were 700 million yards of auriferous gravel which could not be touched, in consequence of the legal action of farmers and others who were inundated with the *débris* from previous washings. In some cases that *débris* had reached a depth of 150 ft., and of course it spread over land which had been, or might be, cultivated. This was a very serious matter in California, and he hoped nothing of the kind would occur in Spain, where the mining laws, so far as his experience went, were very liberal.

Mr. Martin Wood said his interest in this matter was rather personal than scientific, having known Mr. Sowerby in other fields, where gold was very scarce, but where he knew he had experience, as an engineer and geologist, almost from Cape Comorin to the Himalayas. One thing that struck him with astonishment, however, was that so little had been done in modern times in these regions which, according to the statistics, had yielded such large returns in the early part of our era. Of course he knew that the Spaniards were rather lazy, but still, like other people, they were fond of gold, and seeing that these deposits were in such an accessible region, he was astonished that the mines had been so neglected.

The Chairman said he was rather discouraged from saying anything, because on a former occasion, when speaking of gold in India, what he stated, which was really in caution, was actually used as a means of promoting speculation. He then referred to the necessity, in all such investigations, of taking care that operations were carried on for mining, and not for Stock Exchange purposes, and pointed out the necessity of first endeavouring to ascertain the real value of the deposits. He said that although it was quite true that when large sums were paid for estates supposed to contain gold, there was no loss to the public, as it was a mere transfer of money from one hand to the other, yet it might be attended with considerable loss to individuals; and, as they knew, large sums had been paid for estates which had produced nothing. Worse than that, much capital had been expended in machinery, before it was ascertained whether there was any stuff to be worked at all. The consequence was that experiments were only now being made which ought to have been made in the beginning, and that gold, in small quantities, was being produced. This, however, was not a case of the same kind. The deposits to which Mr. Sowerby called attention were of a different kind, and the circumstances were different, except that in each case there was an attempt to re-work, on a large scale, deposits which in ancient times yielded large quantities of gold. In each case, also, although mining operations on a large scale had not been carried on continuously, the people had never ceased to work the gold. Mr. Sowerby, however, had no reason to fear any reference to India; as Mr. Martin Wood had said, his labours there were well known, and only yesterday he was reminded by Sir Wm. P. Andrew of the value of Mr. Sowerby's investigations into the iron deposits of India, when employed for that purpose by the Government, at the time of the Mutiny. At one period, he (the Chairman) had paid great attention to ancient gold workings, so far as information could be gathered from books, and from passages in Pliny and other authors. He had written a series of articles on the engineering of the ancients, which would be found in the old volumes of the *Civil Engineer and Architects' Journal* forty years ago. To some extent, these things should be a warning to us not to suppose we were engaged in one career of continuous progress, and were so much cleverer than those who preceded us. It was true the Romans had not the appliances we had, but they made up for want of machinery by employing mechanical power in the shape of cheap human labour. If they employed 50,000 slaves on these workings, which was quite within their compass, they would not spend any great amount on their keep; for it was well known that slaves in the mines in ancient times were very cruelly treated, as indeed they were in later times. Therefore, the quantity of gold which Pliny stated to have been produced might have been obtained with great profit to the State. It was thought by many that these workings began with the Romans, others thought they began with the Phœnicians, and when one considered what took place with regard to the silver workings of the Greeks in the neighbourhood of Athens, one might doubt whether the Romans were the authors of ancient mining. At the present day, in Cairo, you might have bags of Athenian silver coins offered you at almost the current value of the metal. The Athenians having a large supply of silver, became the mint masters to the ancient world, and the owl, the emblem of Athens, was still to be seen on many coins. Those workings also were carried on by slave labour. The Greeks must have learned from someone before them, and the Greek writers had to seek an author for the arts they employed. One author had a fancy for the Phœnicians, and Herodotus was very fond of the Egyptians, but there could be no doubt that there were others earlier than either in Spain, without much doubt, the Iberians. Then, after a period

of improvement, the world had been thrown back, and it was a melancholy reflection that we did not find in history a record of continuous progress; but, on the other hand, there was this consolation, that there had never been an epoch of devastation and barbarism which had not been followed by a recovery of civilisation in the fulness of time. Mr. Martin Wood had put a very pertinent question, why, after these deposits had yielded very large returns for something like 300 years under the Romans, and probably for centuries before that, these large workings had ceased, and only yielded an occasional occupation to the local population. The answer would be found in the history of Spain. These regions were for centuries the scene of war. On these grounds the descendants of the Goths fought against the Mussulman invasion of Europe; and from these mountains the Mussulmans were driven back, until at last they were expelled from the south of Spain. These wars, in which the Black Prince and other Englishmen participated, prevented the population of Spain for several centuries from occupying themselves in peaceful pursuits. It happened, too, that the moment Spain was free from the contest with the Moors, another event took place, which was perhaps more injurious to its mining operations than anything else; he referred to the discovery of the New World. The result of that, although in the eyes of the Spanish monarchs it added to the wealth and power of Spain, was undoubtedly to very much throw back old Spain itself. All the best men migrated to the New World, and Mr. Sowerby had seen there much finer examples of Spanish enterprise than he had found in Spain. The conquerors of America were not lazy men, or wanting in enterprise; they carried out wonderful works, but what they did abroad was an injury to enterprise at home. In ancient times, these mining operations were carried on by slave labour; but since what was called the discovery of gold in California—though it had been worked by the Indians under the Jesuits for centuries—the Americans had applied processes of water irrigation, which enabled them to work minerals of very low quality. When they heard of 2 dwts. to the ton, they might question whether it was an adequate return for the expense of the process; but when they remembered that even the Romans were able to bring great water-power to carry down the gravel and to extract the gold, it would be evident that, with modern appliances, even these low-class minerals might afford materials for some of the most profitable operations of gold mining. This explained how this subject now became of practical importance, and also why it should be brought before the Society. The Society of Arts was founded, upwards of a century and a half ago, for the purpose of developing new resources in these islands and in our colonies abroad. At the present time we wanted new fields for the development of industry and commerce, and it was most desirable that men who thought they had something new and useful to bring forward should be encouraged to do so. It had always seemed to him that, in the way in which the Society had fulfilled that function, it had done a great amount of good, and deserved the thanks of the public. If, when any particular subject was brought forward, people allowed themselves, through their own ignorance, to be deluded, that was their own fault, not that of the Society. We had already had a great deal to do with mining in Spain, and with mineral operations there, and had largely profited by them. We had a hand in the development of the lead industry, and also in the reduction of silver from lead ores by the Pattinson process, which had also been largely used in this country in connection with Spanish ores. At one time the production of silver in Newcastle was 200,000 oz. a year. We also had a large interest in the extraction of iron ores in Spain by those processes devised by the late Chairman, Sir William Siemens, and others, who had done so much for the improvement of iron and steel industry. Another instance was the copper and sulphur works in Spain, which, under the auspices of English engineers, had been carried out on such an enormous scale, and largely employed English machinery. All this showed that in the introduction of a new industry, even in a country so little remote as Spain, the national interest would be very largely involved, and that a discussion here regarding it might tend to call the attention of practical men and capitalists to new sources of wealth at a time when they were so much wanted. In conclusion, he proposed a hearty vote of thanks to Mr. Sowerby for his valuable paper.

Mr. SOWERBY, in reply, said there was much less likelihood of any cause for litigation from the gravel carried down by the rivers in Spain than had been the case in California. He was not personally acquainted with that country, but, from what he had heard he believed that mining had been carried on there in the most reckless manner, and that the *débris* had been allowed to overflow the country in a way which made it not at all surprising that litigation should ensue. The Americans went ahead, and did not care what the consequences were, until they ran their heads into a noose, and then they had to draw back. If the works in California and Columbia had been carefully planned, with a view to utilise the stuff which was carried down, instead of doing an injury, it would have done a great deal of good in the way of reclaiming the lower grounds. This was what they were now beginning to do, after having caused an immense amount of destruction. Another point to be remembered was that the tide on the west coast of America was very small, whereas on the Atlantic it was very great, and consequently there never could be the same accumulation of *débris* at the mouth of the rivers, supposing the stuff ever found its way down to them, which was very doubtful, as there might be in California. For instance, the River Thames had an immense amount of *débris*

carried into it every day by means of the sewers, and if it were not for the tidal rise of 18 feet it would silt up in a few weeks and become unnavigable. The amount of water which came into the Thames every twenty-four hours was enormously large. That was precisely what took place in California; it was not likely to be the case in Spain; but independently of that, these deposits were a long way up in the mountains, and the rivers were very rapid indeed. Near the streams again there were gorges of great depth which could be filled up, especially near the Guerna, the Caprera, and the Sil. Las Medulas was a large ravine which could not be filled up for many years. Litigation as to other matters connected with mining was not likely to occur in Spain, because the miuing laws were exceedingly exact and well defined. All the minerals belonged to the Government, and once the right of mining was granted it was a freehold as long as the dues were paid. With regard to Mr. Martin Wood's question, he would just say that if a similar paper to this had been read with regard to the Indian gold-fields, the great mistakes which had been committed there would never have occurred. About 12 or 18 months ago Dr. Ball read a paper on India, and he then suggested, as he had done before, that the companies should form an association for supporting each other, or that the mines should be taken in hand and worked by the Government, by the scientific corps. At a distance of 7,000 miles, he defied any small company, however well organised, to continue efficiently its supervision over a little affair of that kind. Accidents would occur, the superintendents got ill, and there was no one to take their place, whereas, if the mines had been carried on by the government, they had an immense supply of convict labour which could be used for the rough work, and the operations might have been very profitable. He was glad to find that some companies were now proceeding more carefully, and was quite certain that ultimately the the Indian gold mines would be successful. In addition to the reasons given by the Chairman why gold mining had been discontinued in Spain, he should mention that there was a decree of Isabella which put a stop to all mining for the precious metals for many centuries, and this had only lately been repealed. In all parts of Spain which he visited, whether in the copper, lead, silver, iron, or tin districts, he found immense deposits from old workings. At Rio Tinto, and on the southern coast, near Carthagena, the same thing occurred, and it is was only recently that these old mines had been re-opened by English capital. Again, the part of the country he had described was, until quite recently, almost a *terra incognita*, though it had now become more accessible. Las Medulas was quite a mystery, except to a few who were believed to be the descendants of those who worked the mines in the times of the Romans. There were one or two villages containing people who were quite separate and distinct from the other Spaniards; they still worked the mines, and were supposed to be descended from the old miners. The quantity of gold they obtained annually was about £5,000 worth, which was chiefly collected in the smaller streams, and sold to the bankers in Spain. More recently the railway companies had given greater employment, and there was not the same inducement to wash for gold.

The CHAIRMAN remarked that probably what took place there was the same as in other parts of the world; when the people had no other employment they went out and did a day's washing.

Mr. SOWERBY said that was so. They made from three to ten francs a day. Some expert washers never made less than ten francs. At the present day there was no necessity for 60,000 labourers to carry on these mines. There was plenty of water power, and with skill and capital it would be very extraordinary if modern engineers could not devise means for working the mines without any injury to the land, or any great difficulty as regards bringing the water to bear. 88 per cent. of the gold in the world was obtained from alluvial deposits, and only 12 per cent. from quartz mining; but he could assure Mr. Moon, who he knew was interested in this question, that there were immense quartz reefs in the district in question which could occupy any amount of machinery, if it were found more profitable to work in that way. In one part of the country, north of the Sil, there were reefs of quartz containing gold and tellurium twenty or thirty miles in length.

TWELFTH ORDINARY MEETING.

Wednesday, February 25, 1885; WILLIAM E. RICH, M. Inst.C.E., in the chair.

The following candidates were proposed for election as members of the Society:—

Chadwick, Jesse, 6, Strand-terrace, Derby.
Mumford, Thomas William Bassett, 1, Glendale-villas, Sylvan-road, Wanstead, Essex.
Rawlins, Thomas, 45, King William-street, E.C.
Schlentheim, Ludwig, 40, Holborn-viaduct, E.C.
Smith, Josiah, 51, Park-end-road, Gloucester.

The following candidates were balloted for and duly elected members of the Society:—

Best, Charles William, 18, Abingdon-street, Westminster, S.W.
Gordon, John, 10, Holland-park-gardens, W.
Horton, Alfred E., 104, Manor-road, Brockley, S.E.
King, Bolton, 28, Commercial-street, E.
Moffatt, George, 29, Eastbourne-terrace, W.
Petheram, Frederick Wm., 2, Lombard-court, E.C.
Ravenshear, Albert Francis, 11, Spencer-road, Herne-hill, S.E.

Redwood, Boverton, F.C.S., 85, Gracechurch-st., E.C.
Smallman, Henry, 5, Hammelton-crescent, Brixton-rise, S.W.
Swan, Joseph W., Lauriston, Bromley, Kent.

The paper read was—

PAST AND PRESENT METHODS OF SUPPLYING STEAM-BOILERS WITH WATER.

W. D. Scott-Moncrieff, M.Inst.M.E.

I have not been able to discover any record of boiler feeding earlier than the end of the the 17th century. In 1702, Thomas Savery printed an account of his engine (84 pages, 12mo.), entitled "The Miner's Friend, or an engine to raise water by fire described; and the manner of fixing it in mines, with an account of the several uses it is applicable unto, and an answer to the objections made against it." Here we have the first description I have found of the means employed for filling a steam-boiler with water and of afterwards feeding it. The first process of filling, though it seems somewhat primitive. does not differ essentially from one that is frequently adopted at the present day, in removing the cover of a man-hole and charging the boiler with water from a hose-pipe. Savery says, referring to the drawing—

"Before you make any fire, unscrew the two small gauge-pipes and cocks, G and N, belonging to the two boilers, and at the holes, fill the great boiler, L, two-thirds full of water, and the small boiler, D, quite full; then screw in the said pipes again as fast and tight as possible, and light the fire under the large boiler at B I. The process of feeding the boilers with water, after the engine had been started, was carried out by means of the pipe, E, which allowed of the water passing by gravitation from the stand-pipe, S, into the small boiler, D, through the cock, E, and afterwards from there into the great boiler by means of a greater steam pressure in the former."

Feeding by gravitation continued in use after Savery's engine had been superseded, and so long as a low steam pressure was used for the production of a vacuum only, as in the early atmospheric steam-engines of Newcomen, Smeaton, and Watt. In the atmospheric steam-engine of Smeaton. constructed in 1772, an arrangement was made for feeding the boiler from the hot well, and this is shown in the drawing on the wall. T is the feeding pipe to replenish the boiler with water from the hot well. It is vertical, and goes more than half-way to the bottom of the boiler, so that the lower end is always immersed in the water. The upper end, which rises up through the dome of the boiler, is open at top, with a funnel or cup upon it. This upper part has a lateral branch out of the hot well, with a cock to admit either a large or small quantity of water, as occasion requires, to replace what is evaporated.* A similar arrangement was used in the Chase water fire-engine of 1775. The plan of obtaining water from a hot well placed above the level of the steam-boiler was no longer available when Watt's invention of the separate condenser began to displace the older forms. In several instances he made use of the old atmospheric cylinders as steam jackets for his smaller steam cylinders, in which the piston was moved through both strokes by the aid of steam pressure in addition to that of the atmosphere; but as his separate condensers and hot well were generally placed below the level of the boiler, it became necessary to use a pump, in order to raise the water to a sufficient height to fall into the boiler against the pressure of the steam when the feed-valve was opened. This arrangement is shown on the drawing on the wall, which illustrates Watt's engine for draining mines (1788).

The next improvement seems to have been the automatic feeding of the boiler by means of a floating stone balanced by a counter-weight working on a lever. This plan was adopted in Boulton and Watt's 10 horse-power rotative engine (1787 to 1800) as shown on the drawing. The low pressure of steam which was in vogue, even at that time, is illustrated by the comparatively small head of water which was sufficient to overcome the boiler pressure when the feed was going on. In the case of the last-named engine, it was only 8 feet. The column of water in the stand-pipe of course varied in height with the changes in the steam pressure in the boiler against which it rested, and Watt took advantage of this to provide the means for working an automatic damper, which rose and fell with the falling and rising steam. This arrangement is shown on the drawing, which illustrates the boiler of Boulton and Watt's 36 horse-power engine, constructed at Soho in 1808.

As facilities increased for the manufacture of stronger boilers, the pressure of steam employed was higher, and in course of time,

* "Farey on the Steam-Engine," p. 137, 4to. London, 1827.

a stand-pipe of moderate height ceased to be available as a means of replenishing the supply of feed water, and a pump became essential. This was worked from the beam in the case of the beam-engine, and from the various moving parts in other varieties of engines. It would be impossible to give anything approaching to a complete account of the various forms of feed-pumps which have been used from first to last in connection with the steam-engine. When force-pumps became necessary, on account of the increase in the boiler pressure, which has been the invariable accompaniment of improvement and economy in the use of steam, the simple ram plunger was frequently employed, the suction and delivery being arranged by means of inlet and outlet valves in the casing or body of the pump. This arrangement, known as the plunger or force-pump, was invented by Sir Samuel Morland in 1675. This invention has an additional interest in being associated with the first application of the gland stuffing box. The still older arrangement of having the delivery valve fixed in the plunger was also very common. In course of time the arrangements of the engine-rooms and boiler-houses of large establishments were put upon a more independent footing in relation to each other. In the earlier practice, the steam-boiler is generally found in close proximity to the engine, and in most cases one man was no doubt all that was necessary for attending to both. But where several boilers were constructed in a building set apart for the purpose, and in situations where the dust of the stokehole was not allowed to reach the engine-room, and a certain amount of separation was provided on this account, it became advantageous that the man in charge of the boilers should be provided with an independent means of feeding them. There was also a disadvantage in being dependent upon some moving part of the engine as the means of working the feed-pumps, especially in the case of industries where steam was employed for other purposes than the supply of motive power. In these cases a feed-pump worked from the main engine; if its dimensions were calculated for nothing more than supplying the boiler with the equivalent of water evaporated in the production of steam for the use of the engine only, it would prove insufficient, and at the best it was a cumbrous method of feeding a boiler, especially when the engine was a large one. These considerations give rise to a demand for a small independent pumping-engine, which has since become universally known as the donkey-pump. It would be equally impossible to give an account of all the thousand and one forms of these useful machines which have been brought before the public since their first introduction. Even the types are so numerous that it would occupy much more time than is at our disposal to-night. I have here one or two specimens which have been kindly lent to me by the makers for the purpose of illustrating this paper.

Donkey-pumps, like other pumps, may be divided first into the two classes of lift and plunge-pumps; the former arrangement, although much the oldest, was never well suited for a resistance of high pressure, though, as we have already seen, it answered very well in the case of the early low-pressure engines. The different varieties of the plunger-pump, as already stated, are legion. The next divisions into which donkey-pumps may be catalogued are (A) where the arrangements for applying the motive power takes a rotary direction, giving momentum to a fly-wheel, for the purpose of carrying the cranks over the dead centres, or giving movement to the crank of the fly-wheel by means of a sliding block and crosshead, the steam piston-rod and the pump-plunger being in line and rigid, or communicating motion to the crank of a fly-wheel by means of a connecting rod attached to a straight piston-rod, the diameter of which is enlarged so as to form a pump-plunger; and (B), in which the valves of the steam cylinder are arranged in such a manner that the steam gains access to one or other of its alternate ends whatever the position of the piston may be, so doing away with the necessity for a fly-wheel altogether. Messrs. Tangye, of Birmingham, have long been identified with a well-known arrangement of this description known as the "Special" Pump; and an American invention, known as the Universal Pump has helped to establish the principle in the public favour. Of late years this kind of apparatus has had a large development, and is used for a great many purposes besides the feeding of boilers. The three different kinds of pumps just spoken of, which represents types of the modern donkey-pumps, are shown in the annexed woodcuts:—

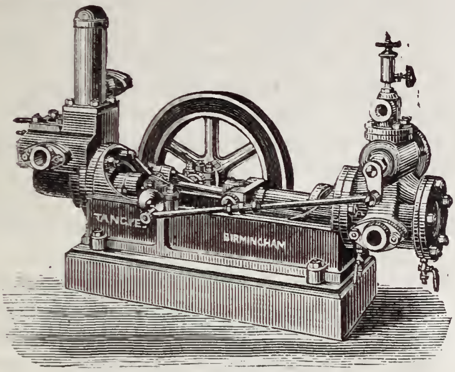
Fig. 1 (p. 373) shows a pump giving rotary motions to a fly-wheel, and a specimen is exhibited on the platform.

Fig. 2 (p. 373) shows a pump with a sliding block and cross-head, serving the purpose of a

connecting rod, and communicating by that means rotary movement to a fly-wheel.

Fig. 3 shows a pump in which the reciprocating motion is carried on without the aid of a

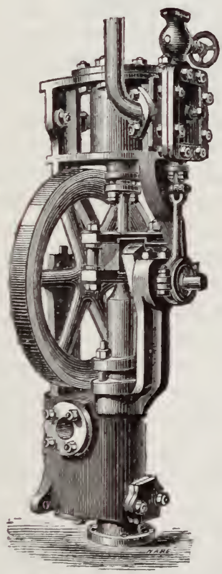
FIG. 1.



Ram-pump and Boiler-feeder, by Tangyes, Limited, in which rotary motion is communicated to a fly-wheel.

fly-wheel, by means of the valve-gear only, and this also, by the courtesy of Messrs. Tangyes, Limited, I am able to show you on the platform.

FIG. 2.

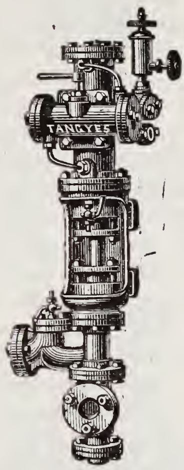


Ram-pump, by Messrs. Roger and Company, of Stockton-on-Tees, with a sliding block communicating rotary movement to a fly-wheel.

There are, of course, a very great number of most excellent pumps of various kinds, well known for their good qualities, which the limited time at our disposal makes it quite impossible to refer to. I have illustrations on the walls of excellent pumps by the Coalbrookdale Company, Mr. Coles, of Southwark, and Mr. Hanson, of Bradford.

Objection is sometimes made to the donkey-pump, on the ground of its being an independent steam-engine and pumping machine, and therefore requiring to be made up of a large number of working parts. Among these, a great many must be common to every form of steam-engine, such, for instance, as the valve, the piston, the excentric, the crank, or analogous mechanism, not to speak of the pump-plungers, valves, &c. It is also a complaint against donkey-pumps that they are somewhat extravagant in the consumption of steam, and

FIG. 3.



Ram-pump and Boiler-feeder, by Tangyes, Limited, in which the reciprocating movement is carried out by the valve gear only.

this is no doubt the case among the smaller sizes where the friction must be considerable in proportion to the work done, and where wear and tear is not likely to be taken notice of as a cause of loss. If there are any advocates of donkey-pumps present, I dare say, if they are good enough to join in the discussion, they may demolish these objections, or at any rate point out many countervailing advantages.

Whether the objections referred to weighed with inventors or not, it is hard to say, but at any rate the engineering world was astonished, about 27 years ago, with the announcement that a French inventor, whose name was already celebrated in connection with other matters, had discovered a means by which the steam from a boiler could be so

directed as to take up a body of feed water, either cold or at a considerable temperature, and force it into the boiler against the pressure of the steam which supplied its motive power. The inventor was Giffard, and the apparatus was the one since popularly known as the "Injector."

The announcement of the apparently paradoxical phenomenon was at first received with incredulity, and there is little doubt that in its first stage the invention seemed to justify the want of belief which was almost universal regarding it. Its novelty and utility, as well as the prospect of a wide market in the event of its proving a success, induced a celebrated firm of engineers in Manchester to take up its development, and this, to some extent, justified the remark made by an engineer last year, in a discussion upon other methods of supplying steam-boilers with water "that the injector, though a foreign invention, was practically born in Manchester." The instrument became a great success, and brought a fortune both to the inventor and his licensees. Of its performances, and their scientific explanation, it is not so easy to speak. I have here a drawing of what may, now-a-days, be called an old type of injector. It is one of a series which has been kindly lent to me by Messrs. Graham and Craven, of Manchester.

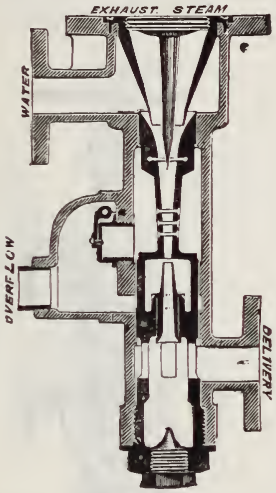
In every form of injector, it appears to be a preliminary essential to their efficient working, that a supply of steam should be allowed to pass through them for a short period of time, considerably in excess of what is necessary for working them after the water has begun to pass into the boiler. The functions of this first movement of steam is to clear the pipes and passages of air, the presence of which prevents the formation of a vacuum; but this once being established, a much smaller supply of steam suffices for its future working. This fact in the earlier forms of the injector necessitated a certain amount of manual adjustment on the part of the attendant, and it not infrequently happened that the preliminary passage of steam raised the whole apparatus to a temperature at which it ceased to be capable of doing its work at all. The more improved forms are now spoken of as self-acting or automatic, inasmuch as provision is made by which the steam first passes in a sufficient volume to discharge the air adherent to the passages, and then readjusts itself to the smaller quantity necessary for doing the work of forcing the water into the boiler.

I am not prepared to give a technical or even a popular account of how the injector performs its somewhat mysterious task, but certainly, in the early days of the invention, it was generally believed that the velocity of the steam passing through the injector from the boiler, played a very important part. This velocity was of course dependent upon the steam pressure. Once obtain the conditions under which a column of water was induced to move at a high or even a moderate velocity, and its passage into the boiler became quite explicable. The velocity must be multiplied by the weight of the moving column, and when these factors are considerable, a state of things exists, in many respects analogous to the water column in the hydraulic ram, in which we know that momentum does extraordinary duty in overcoming the resistance of a high head of water in a state of repose. Recent inventions have shown that the velocity of the steam has little or nothing to do with the velocity induced in the column of water. Injectors are now arranged so as to work with the exhaust steam from non-condensing engines, on its passage to the outside air, at a pressure little if anything above that of the atmosphere. An interesting illustration of this principle has been developed by Messrs. Hamer, Metcalf, and Davies, in which the exhaust steam does all the duty which was formerly performed by the "live" steam, returning, at the same time, a large amount of heat to the boiler which would otherwise have been wasted. In this form of injector an ingenious arrangement of nozzle with a self-adjusting flap has been devised, so as to allow, when the feeder has been stopped and re-started, that the extra flow of steam should pass until a vacuum is formed, when the flap is sucked in, constricting the passage to the smaller requirements of forcing the water. In this arrangement the supply of water is taken from above the level of the injector. Messrs. Holden and Brook attain the same object by means of slits in the nozzle, and a flap-valve to provide for a free outlet for the first passage of water to the overflow pipe; when the vacuum occurs, this flap-valve closes automatically. It appears, therefore, that the velocity induced in a column of water rushing in to fill a vacuum—which is rendered continuous, as it were, by the intrusion of a jet of constantly condensing steam at low pressure—is sufficient to overcome the pressure of steam in a boiler.

I have been favoured with a few woodcuts of different types of injectors, by the courtesy

of the manufacturers, which I have made use of, not to bring one before you more prominently than another, but simply to illustrate the subject, as far as practicable, within the limited space at my disposal. I have no doubt there are many excellent examples which are each worthy of a paper and discussion to themselves. The exhaust steam injector already referred to, the invention of Messrs. Hamer, Metcalfe, and Davies, I am able, by the courtesy of their agents, to exhibit on the platform, and Fig. 4 shows the arrangement of parts devised by Messrs. Holden and Brooke to effect the same object.

FIG. 4.

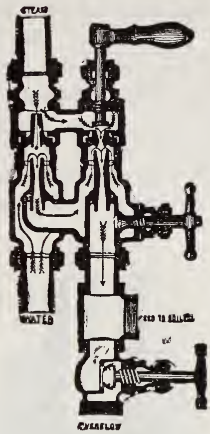


Exhaust Steam Injector, by Holden and Brooke, with slits and flap valve for escape of overflow water,

The Hancock inspirator, to quote from a report by the Park Benjamin's Scientific Expert Office of New York, differs in some important respects from the instruments generally classed under the head of injectors. It consists essentially of a lifting jet and a lifting nozzle, combined with a forcing jet and force nozzle or injector. A section of the instrument is shown in Fig 5.

Messrs. Körting Bros. have adopted a somewhat similar device. The object is to work with either hot or cold water, and with high or low pressure steam, and without the necessity for adjustment of the incoming steam and water. For this purpose two complete injectors are combined. The first, or lifting injector, delivers the water into the second or feeding injector, and as the first regulates the water supply of the second, no special water adjustment is necessary. A section of this very ingenious injector is shown in Fig. 6. Messrs. Fairbairn and Hall, of Manchester, have

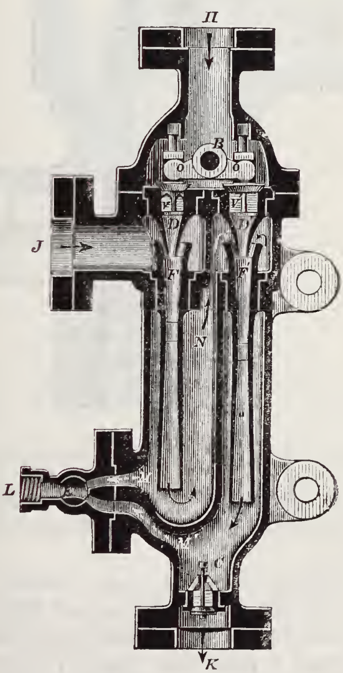
FIG. 5.



Hancock Inspirator.

applied the injector to a variety of purposes besides boiler feeding; one arrangement is called the jetometer, and is used for lifting

FIG. 6.

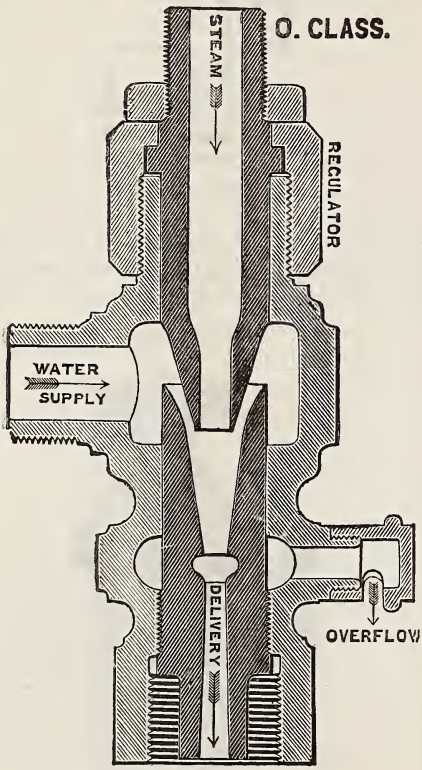


Messrs. Korting Bros. Injector.

water from a low and forcing it to a high level. Fig. 7 represents one of their forcing or water elevating injectors. It is, as shown, very simple

in construction, and the smallest size is sold at a price that illustrates the power of competition, and which would have astonished the manufacturers in the early days of the invention. Messrs. Gresham and Craven, who have kindly favoured me with drawings illustrating the progress of the injector, also manufacture injectors for a great many purposes besides boiler feeding, including the bilge pumping of ships, and their experience accords with others in this, that where the conditions vary greatly as to height of lift, temperature of water, pressure of steam, &c.,

Fig. 7.



Messrs. Fairbairn and Hall's Forcing Injector.

special instruments should be devised for special work. One of the injectors is shown in Fig. 8.

I cannot conclude these remarks upon injectors without expressing my regret that time prevents me from doing full justice to the inventions I have thus hastily referred to, as well as many others. As regards the merits of the injector generally, at least from the view of a special pleader, I cannot do better than quote from a circular of one of the manufacturers I have referred to.

"1. The steam employed in working the injector is returned to the boiler with the feedwater, thereby raising its temperature, and preventing the unequal expansion so disastrous to boiler plates, caused by pumping in water at a low temperature.

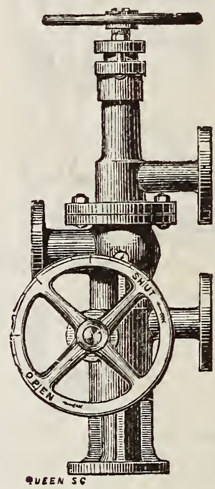
"2. The supply water (through the injector) enters the boiler in a continuous stream, in place of the intermittent action caused by all pumps; in fact, the injector, as compared to a pump, may be considered as a continuous ram with a continuous piston.

"3. The first cost is far less than that of any pump; and, having no parts in motion, the repairs are reduced to a minimum.

"4. They are entirely separate from the engine, and are independent of it, being an adjunct to the boiler.

"They are always ready for immediate use as a fire-engine by simply attaching a hose-pipe to a cock which can be supplied for the purpose."

Fig. 8.

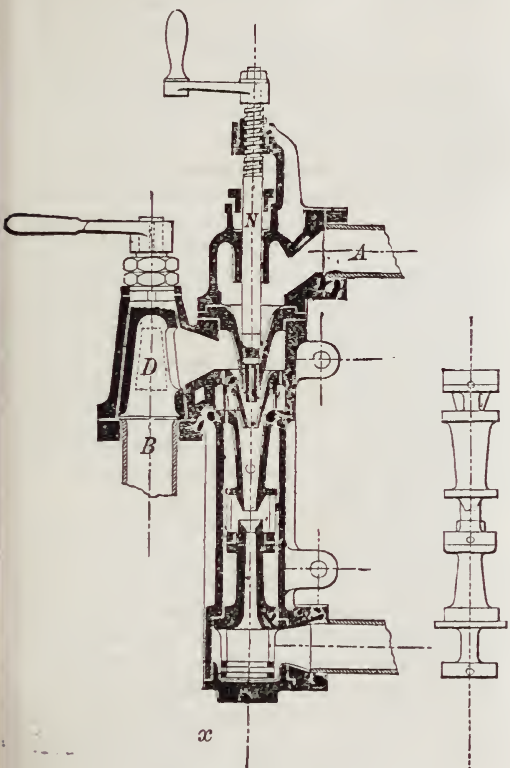


Messrs. Gresham and Craven's Injector.

Although the name of "automatic" is applied to several forms of injectors, this term is only meant to express the capacity of the injector to start working when steam has been turned on by the attendant, or at any rate it does not mean that the water level in the boiler is as it were self-supporting. Attempts have been made to make injectors automatic in this respect, but I have not come across any of them in practice. It will be remembered that James Watt, as shown in the diagram, had adopted a plan by means of which his boilers were fed with water automatically by a stone float, which fell as the water was evaporated, and admitted more water without any extraneous attention. Mr. Charles Cochrane, at a meeting of engineers, in 1882, mentioned the case of an old boiler of the

so-called balloon type, which had been attended to by the same man for thirty years, and, during all that time, the old-fashioned self-acting float and counterweight had never failed him. They had grown old together. One day his ancient ally did fail him, and the crown of the fire-box gave way in consequence. I think this case speaks well for the principle adopted, for if the apparatus had been renewed in time it would, doubtless, have long survived the old engine man. There is certainly a great advantage to be obtained from automatic feeding, so long as the water in the boiler is kept

FIG. 9.

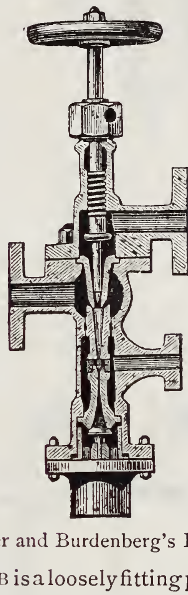


Friedmann's Injector.

to a level within very small limits of variation. James Watt had, no doubt, cogent reasons for adopting the principle, and the avoidance of violent contraction and expansion, leading to great wear and tear of the boiler, was no doubt a principal motive. I do not know of many appliances with this object in view that have been brought prominently before the public.

In August, 1882, M. Couronne, engineer of the Paris water works, reported upon the working of an automatic boiler feeder, the invention of M. Fromentin, which has since been introduced to the public in this country. The arrangement consists of two oscillating chambers fixed upon a disc, which moves through several degrees provided with ports to admit of feed water being drawn into and discharged from the bottles or chambers alternately. The action is regulated by means of a dip pipe, which admits steam when the water in the boiler falls below its lower extremity, and water when the level has risen beyond it. Another form of feeder was introduced by Messrs. Schaffer, of Budenberg, which is too complicated to admit of explanation in this paper. I now go on to describe an automatic feeder, which is wonderfully ingenious, and in which I have taken a great interest for some time. It is the invention of Mr. Alfred Mayhew, and is illustrated in the large diagram on the wall. Fig. 11 (p. 378) is a steam-valve closing against a

FIG. 10.

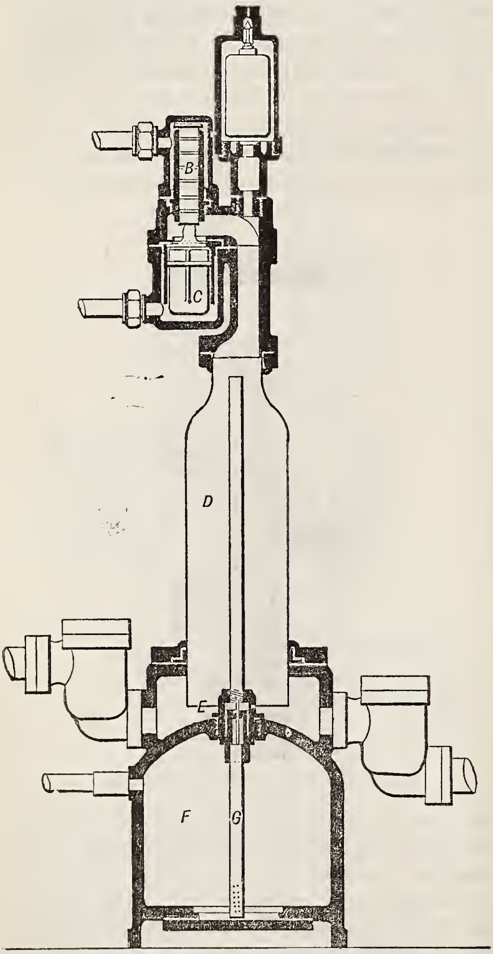


Schaffer and Burdenberg's Injector.

seat above it. B is a loosely fitting piston working in a guide and resting on the steam-valve. D is a copper chamber. F is a casting, forming a reservoir for condensing water, and kept supplied by a pipe from the water in the boiler. This casting has an upper chamber, E, to which are bolted a suction and delivery valve as shown. The branch below the steam valve, C, is connected by a pipe to the steam space of the boiler; the branch above the piston, B, is connected by a pipe reaching down to the water level of the boiler. When the water in the boiler is below the level of this dip pipe, steam at boiler pressure reaches the top of the piston, B, but, when the water in the boiler touches the mouth of the dip pipe, it rises in the pipe and fills it. The pressure above the

piston, B, is then diminished by the weight of the head of water in the dip pipe. The pressure due to the head is the amount by which the pressure above the piston is varied according to the water in the boiler being above or below its normal level. The feeder is placed 2 or 3 feet above the ordinary water level, and stands fully charged with feed water. If the boiler does not require water, the steam valve

FIG. 11.



Mayhew's Automatic Feeder.

remains closed by the pressure of steam below it, and the water cannot, therefore, run out of the feeder. As soon as the water in the boiler falls below the mouth of the dip pipe, the column of water in the pipe is released, and the increase of pressure which then results above the piston, B, forces open the valve, C. Steam is thus admitted above the water in the chamber, D, and the charge runs into the boiler by gravitation. As the water falls in the chamber, D, the steam follows it until the bottom, at E, is reached, when the steam suddenly expands in the enlarged chamber below. This sudden expansion causes such an increase in the velocity of steam through the orifice, at C, that the valve closes, leaving the steam in the chamber, D, considerably below the boiler pressure. The injection water in the chamber, F, being at nearly boiler pressure, is now forced up a pipe, G, and a vacuum is formed in the copper chamber, D. The feeder then re-charges itself with water through the suction valve and supply pipe. When the chamber, D, is quite filled, the water is put under pressure from the injector chamber, F, and should the boiler still require water the steam valve, C, again falls, the counter-weight of the column of water in the dip pipe being absent. These operations continue at the rate of about five times per minute until the proper level is reached, the water again rising from the boiler into the dip pipe so far reduces the steam pressure above the piston, B, that the valve, C, can support its weight and remain closed, and the feeder remains in a state of rest until the water level has again left the mouth of the dip pipe. There is an air-valve fitted to the top of the feeder having a suitable float to allow of air, but not water, to escape. The chamber, E, is fitted with an alarm whistle and fusible plug, which melts when exposed to the presence of steam.

The principle of the injector I have already attempted to explain in a rudimentary manner by referring to the case of the hydraulic ram. In Mayhew's feeder, the water, instead of being forced into the boiler at a considerable velocity, drops into it by the action of gravity, acting through a few feet of height so soon as the boiler pressure is admitted above the contents of the copper chamber already described. In carrying out his improvement, the inventor has depended upon the physical conditions which arise when the atmosphere is once completely excluded from a closed vessel. It then becomes possible to fill it first with steam, and then alternatively with water drawn from a considerable depth when the steam is condensed, the alternating plenum not interfering with the alternating vacuum. The continuous interruption which takes place in the condition of the interior of the copper vessel is one of the most remarkable physical phenomena I know of—first a vacuum, then a plenum, followed by a vacuum, without any extraneous mechanism of any kind, is in its very nature

an invention of the highest interest, and I think the object attained of perfect automatic feeding is of the greatest importance. I believe that future improvements in boiler feeding will be in the direction first given to them by James Watt and other pioneers of the use of steam, viz., the automatic principle. I have wished this paper to be of general interest, and hope that any gentlemen who have a practical knowledge of boiler feeding, or have studied the theory of any appliances which have this object in view, will favour the Society with their observations.

DISCUSSION.

Mr. R. M. LAWES said, for the last twelve years, he had had to do with marine boilers. The first one he had to do with was fed by a Giffard injector, which, as a rule, he found only about one man in ten was able to manage when the vessel had any motion on. The next boat he was in was fitted with what he should call the abomination of a donkey pump; the result of which was that directly the pump started some passenger always burst out with, "Hallo; here's your donkey run away again." Engineers, as a rule, seemed incapable of using any common sense with these small engines; they either worked them so slowly that they did not feed at all, or dashed away at such a rate that they disturbed every one on board. It seemed to him that this new invention of Mr. Mayhew's was one from which a more simple appliance might be developed.

Mr. H. OLRICK said this new automatic feeder seemed somewhat similar to the Fromentin, described as a swinging arrangement, which was alternately filled and emptied by the condensation of steam in a vessel. It would have been interesting had Mr. Scott-Moncrieff been able to give some data as to the economical working of these different inventions, which had been named one after the other without any particular classification of lifters, non-lifters, exhaustive injectors, and injectors with live steam, which was somewhat puzzling. There was no doubt that donkey pumps were, as a rule, abominable, because they were generally ill-made; they used an enormous amount of steam for the work they did, and the exhaustive steam, as a rule, went into the atmosphere without doing any work. The live steam injector was a very useful instrument, especially for lifting water, and showed a certain economy which was now well known. In 1865, Mr. Carrington, then President of the Society of Engineers, speaking on a paper read by his father on the Giffard injector, said if a pump could be made with fewer parts, and made perfectly reliable, there might be some argument in favour of the pump. At that time there was a question whether the injector was more economical than a pump to feed a boiler; but when you came to an instrument like the exhaust injector, where the water condensed was put back into the boiler, and formed from one-seventh to one-fifteenth of the whole steam used in the cylinder, it was one the economy of which might be dwelt upon with a great deal of emphasis. With an automatic boiler feeder you had, as a rule, attendants who were prone to indulge in anything more pleasant than their duty, and if the apparatus went on for several months without requiring any attention, some day a valve would stick, as might happen to any valve, and if not noticed the boiler might suffer very materially. With an exhaust injector, the man was supposed to be continually at his work, and it was an enormous advantage to be able to use water at about 190° without any cost whatever, when using a high pressure engine. If water fed into the boiler were robbed of its sulphates and carbonates of lime, it seemed to him it would be much preferable to an automatic feeder, which required a chamber containing water to condense the steam before the water could be poured into the boiler.

Mr. CHARLES S. MADAN said he could explain a very common cause of what had been described as "the donkey running away." As a rule, these donkey-engines were badly designed, the steam cylinder being much too large for the work it had to do; and, in the second place, not one in a hundred was balanced. There was nothing to take up the energy of the upstroke, when the pump had very often nothing to do but lift the plunger for the water to run in, and consequently the pump had only to do its work one way. It worked steadily enough when driving the water in, but went up with a jerk when the water was flowing into the pump cylinder. If any method of balancing were employed, a pump could be used at an extremely slow speed, with some fair chance of economical working. There was a great deal to be said both for and against the economy of an injector as compared with a pump; and if the arrangements were properly made, about as much could be said for one as the other, except in the case of the exhaust injector, which he could not say much about, as his practice had been entirely with high-pressure injectors. With regard to the first cost, the injector was no doubt the cheapest, but a pump could be made to work as economically in many instances, and he would give an instance of what a pump could do. Some time ago, by the kindness of Mr. Stroudley, of the London, Brighton, and South Coast Railway Company, he was allowed to try an injector on one of his locomotives; the practice being to use pumps, the feed-water in the tender being heated by the exhaust steam, and the exhaust from the Westinghouse pump was also taken into the tender, so that the water was made nearly boiling-hot before it entered the boiler. This system answered so well, that the engines ran with 13 lbs.

of coal per train mile. He put on an injector, and worked it with dead cold water, with the result that it took $1\frac{1}{2}$ lb. more coal. The point was that if you employed proper means of utilising your waste steam, either a pump or an injector could be made economical, and by neglecting this point, either would be wasteful. There were many ways of making an injector economical; the steam used in forcing the water into the boiler being also itself returned into the boiler in a condensed form, there was not the wear and tear, and no power was consumed in moving working parts; but if any system of heating the feed-water by the waste steam water were added, its economy was vastly increased. That could be done either by an ordinary fuel economiser, or a feed-water heater in connection with the exhaust. The same, of course, could be done with a pump. In conclusion, he might say that an injector was in course of construction, and would shortly be introduced, on something the same principle as Mr. Mayhew's invention, which would work automatically, the variation in the height of water in the boiler turning on the steam, and causing it to work.

Mr. J. J. EASTICK asked what was the limit to the temperature of the feed-water which could be fed into a boiler by the exhaust injector, and also if it had been tried with water of considerable hardness. He thought there would be a difficulty from carbonate of lime being thrown down in such an apparatus.

Mr. W. K. BURTON remarked that none of the previous speakers seemed to have seen the Mayhew feeder in actual work, and as he had had an opportunity of doing so, he would state the results. When he heard, about six months ago, that one had been working for some time at a certain place, it struck him that, being apparently very delicate in construction and in the balancing of the valves, it might not act so well in practice as it ought to in theory, and he therefore interviewed the driver who had charge of this feeder. He asked him what he thought of it, and whether it had not given him a lot of trouble, and required to be taken down very often. In reply, the man pointed to a bit of paper which he had put on the gauge-glass, and said that for all the months the feeder had been in use the water had not varied one-sixteenth of an inch above or below the upper edge of that bit of paper, and it (the feeder) had never been taken down. He did not suppose the man had any interest in speaking favourably of it, and therefore it would appear to be quite successful in practical working. The only objection which could be urged against the automatic feeding was that mentioned by Mr. Olrick, that it might be neglected, and in case of an accidental sticking of the valve, the crown of the fire-box might get caved in. At the time Watt introduced his automatic feeder, there was no such thing as a gauge-glass in front of a boiler, but now there was always one, if not two, and if the fireman were such an idiot that he could not, when constantly passing the front of his boiler, notice that the water had altogether left the gauge-glass, he was not fit to have charge of a boiler at all. Another objection which had been urged was that there would be a huge amount of condensation in the copper vessel; but it must be remembered that, except for an occasional moment when the stroke was being made, the copper vessel was not full of steam but of water, when no condensation would go on. The total amount of steam used was that required to fill the copper vessel for every stroke, an amount equal in volume to that of the water put into the boiler; and that was really the merest trifle of waste which could be conceived. It might be that an exhaust steam injector, which was a new thing to him, was more economical, but he doubted it, because he could not see how it could work without putting some back pressure on the engine, though on that point he might possibly be mistaken. He thought, therefore, that this patent of Mr. Mayhew's was a practically good thing, that there was no danger in using it, and that it was about as economical as a feeder could be.

Mr. H. OLRICK said he had a diagram in his pocket, taken before and after the filling of the exhaust steam injector on a high-pressure engine, which showed about $1\frac{1}{2}$ lb. less back pressure after than there was before. The explanation was extremely simple. A certain amount of steam had to go to the injector and become condensed, to make it operate, and consequently the back pressure on the engine must be proportionately less; as that amount was probably about one seventh the total amount of steam used in the cylinder, it must show a great economy, when it both reduced the back pressure, and put the steam back in the shape of pure water without any loss.

Mr. WILLIAMS remarked that, with regard to the amount of steam used in the Mayhew feeder, Mr. Burton had pointed out that it was only what was condensed in the copper vessel; and that was sent into the boiler and was not lost. The only loss of heat was by radiation just when the stroke was being made. With regard to the exhaust injector, it appeared to him very much like a feed pump; if the engine were standing, you could not put water into the boiler. With regard to the possibility of the apparatus sticking, he would point out that there was a whistle fixed upon it, and if at any time the feeder did not act, this at once gave an alarm. He had had opportunities of testing it, and had never known it to fail.

Mr. WALES asked if the feeder could be depended on solely, or if it were used in combination with a pump?

Mr. MADAN, in reply to the question put by Mr. Eastick, said that 70° was about the highest temperature at which feed-water could be used with the

exhaust injector. With regard to the deposit, it was the same as in any other instrument using hot water of that character. There would be a deposit, and it had to be cleaned out occasionally. Mr. Olrick was quite correct with regard to the back pressure being removed by the exhaust injector. He was at Messrs. Sharp Stewart's when the experiments were made, which resulted in the invention of the exhaust injector, and had great opportunities of studying the question. There was no doubt it did very materially reduce the back pressure, and consumed a great amount of exhaust steam.

The CHAIRMAN said the first question, with regard to any apparatus for feeding boilers, must be its safety. It would be impossible to adopt any one of these ingenious appliances, unless it could be relied upon to keep the boiler fairly supplied, not to leave you in the lurch when there was a great demand for steam, and if it stopped, to be readily set to work again. The amount of steam power required for feeding was extremely small compared to the steam given off by the boiler for useful purposes. After reliability, the next consideration was simplicity, and there was evidently a tendency in this direction in the design of injectors. Next came economy in working results. No doubt any apparatus which returned the steam or the heat which produced power, or rather so much as was left after developing the power necessary for feeding, to the boiler, was an economical apparatus, and in that category came all the injectors, including this new one. Looking back to the old apparatus of float gears, which were used in all the original types of low-pressure engines up to thirty or forty years ago, one was struck with the fact that no such automatic apparatus were now ordinarily in modern boilers, but there were many practical reasons for this. One must remember that ball-cocks were universally used and relied upon for water supply, but possibly anything of that kind was more difficult to keep in order in a steam-boiler, in consequence of the clogging of the working parts. This reminded him that it was a weakness in any apparatus of the injector kind to have small delicate working parts, when required for pumping certain qualities of water, which were liable to clog those parts, and this seemed of especial importance in Mr. Mayhew's apparatus. In speaking of the relative suitability of a feed pump, a donkey-pump injector, or automatic boiler feeder, it must be remembered that an engine having uniform duties generally supplied its boiler most satisfactorily with a feed-pump, which required very little adjustment on the suction side to keep the boiler steadily supplied for many hours together; but when an engine had intermittent and variable duties, such as a locomotive, or rolling-mill engine, or when the engine was far removed from the boiler, undoubtedly the feed-water motor should be near the boiler, and independent of the engine action. The aim in all these apparatus should be to avoid small delicate working parts, and to avoid relying on small powers or pressure to actuate those parts; if you had only a pound or two on the square inch to work a small valve, sooner or later that valve might be held so fast by some accidental cause, that it would not act at all.

Mr. SCOTT MONCRIEFF, in reply, said the large scope of the subject must be his apology for not having gone into different matters of detail as he could have wished. Mr. Olrick had expressed his regret that such an important subject as the exhaust injector, which was a very remarkable advance, should not have been dealt with at greater length, but he had trusted to that gentleman, or some other representative of the principle being present, who was better acquainted with it than himself, and in that he had not been disappointed. The question asked as to the available temperature had already been answered by a gentleman who appeared to have had peculiarly favourable opportunities of studying the subject. The objections pointed out by the Chairman were really of a most practical kind, such as would occur to the mind of the most experienced steam user. The danger of clogging, or of any failure in the working of a delicate part was, more or less inconsistent with that element of reliability which, as the Chairman had pointed out, was after all the most important point; but with regard to the Mayhew feeder, the apparently delicate valve arrangement was one which had been considerably simplified, and the margin which existed, representing one or two pounds pressure as being all available for putting the apparatus to work, had also been materially increased. He had introduced this invention as much from its scientific bearing, and as being a most ingenious move in a direction which he thought would prevail in all apparatus for feeding boilers—the natural tendency of invention being towards automatic action — as because he had taken considerable personal interest in it. The whistle had warned the engineer against the failure of water in a way which had proved very satisfactory. In cases where a short supply of rain water had run out, this whistle had given warning in time, before any alteration in the level of the water beyond a very small fraction of an inch had taken place.

The CHAIRMAN inquired if this apparatus were audible in action.

Mr. SCOTT MONCRIEFF replied that it was audible, but not by any means noisy.

Mr. JAMES HUMPHREYS said that he was now engaged in some experiments with a view to chemically treating water so as to precipitate the impurities, and allow only absolutely pure water to be introduced into boilers. This was a matter of great importance in all injectors, and he hoped at some future time to have an opportunity of bringing his results before the Society.

The CHAIRMAN then proposed a vote of thanks to Mr. Scott-Moncrieff, which was carried unanimously, and the meeting adjourned.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The literature of the Inventions Exhibition will differ considerably from that of the two former Exhibitions. No handbooks are to be prepared, but the prefaces to the various groups in the catalogue are intended to a large extent to supply their places. The catalogue will contain twenty-three prefaces, written by the first authorities of the day upon the particular subjects entrusted to them. The following is a complete list of these prefaces :—

Group I.—Agriculture, Horticulture, and Arboriculture—Mr. H. M. Jenkins.

Group II.—Mining and Metallurgy—Mr. H. Bauermann, F.C.S.

Group III.—Engineering Construction and Architecture—Mr. Arthur Atchison, M.A.

Group IV.—Prime Movers, and Means of Distributing their Power—Mr. William Anderson, M.Inst.C.E.

Group V.—Railway Plant — Captain Douglas Galton, F.R.S., C.B.

Group VI.—Common Road Carriages, &c.—(Same as Group V.).

Group VII.—Naval Architecture—Sir E. J. Reed, K.C.B., M.P., F.R.S.

Group VIII.—Aeronautics—(No preface).

Group IX.—Manufacture of Textile Fabrics—Mr. Swire Smith.

Group X.—Machine Tools and Machinery—Prof. Unwin, B.Sc.

Group XI. — Hydraulic Machines, Presses, Machines for Raising Heavy Weights, Weighing, &c.— Sir William Armstrong, C.B., F.R.S.

Group XII.—Elements of Machines—(No preface).

Group XIII.—Electricity—Prof. Oliver Lodge, D.Sc.

Group XIV.—Apparatus, Processes, and Appliances connected with Applied Chemistry and Physics.—Professor Armstrong, F.R.S.

Group XV.—Gas and other Illuminants—Mr. A. Vernon Harconrt, M.A.

Group XVI.—Fuel, Furnaces, &c.—Mr. G. Snelus.

Group XVII.—Food, Cookery, and Stimulants—(No preface).

Group XVIII.—Clothing—(No preface).

Group XIX.—Jewellery—(No preface).

Group. XX.—Leather, &c.—Mr. W. Y. Dent, F.C.S. F.I.C.

Group XXI.—India-rubber and Gutta-percha, &c.—Same as Group XX.

Group XXII.—Furniture and accessories, Fancy goods—(No preface).

Group XXIII.—Pottery and Glass—(No preface).

Group XXIV.—Cutlery, Ironmongery, &c.—(No preface).

Group XXV.—Fire-arms, Military Weapons and Equipment, Explosives—Col. Sir Henry Nugent, K.C.B., R.E.

Group XXVI.—Paper, Printing, Bookbinding, Stationery, &c.—Dr. Hugo Müller, F.R.S.

Group XXVII.—Clocks, Watches, and other Time-keepers—Mr. E. Rigg, M.A.

Group XXVIII.—Philosophical Instruments and Apparatus—Prof. G. Carey Foster, M.A., F.R.S.

Group XXIX.—Photography—Captain Abney, R.E., F.R.S.

Group XXX.—Educational Apparatus—(No preface).

Group XXXI.—Toys, Sports, &c.—Mr. E. Lester Arnold.

Group XXXII.—Musical Instruments and Appliances constructed or in use since 1800—(No preface).

Group XXXIII.—Music Engraving and Printing—Mr. Barclay Squire.

Group XXIV.—Historic Collections—(Same as Group XXXIII.)

The first part of the catalogue is already in the hands of the printers.

Notes on Books.

GLASS PAINTING: a Course of Instruction in the various methods of Painting Glass. By Fred. Miller. London: Wyman and Sons.

POTTERY PAINTING: a Course of Instruction in the various methods of working on Pottery and Porcelain. By Fred. Miller. London: Wyman and Sons.

These two volumes, written by the same author, are similar in design and treatment, and are both fully illustrated. The author states that he has treated his subjects to some extent theoretically as well as technically, because he considers it as important to know "what to do" as "how to do it." In the work on glass painting he first treats of tools and materials, of tracing and staining, and then of the various effects to be obtained, passing on to discuss the treatment of glass, and ending with a chapter on ecclesiastical glass painting. In the book on Pottery, the author first deals with the effects of the different colours to be used, and then devotes attention to landscape painting and to figure painting, both in over and under-glaze.

ON THE DISCOVERY OF THE PERIODIC LAW AND ON RELATIONS AMONG THE ATOMIC WEIGHTS. By A. R. Newlands. London: E. and F. N. Spon. 1884.

This little book consists of a reprint of the papers

contributed by Mr. Newlands to the *Chemical News* in 1863-66, before M. Mendelejeff had published his researches on Periodic Law, and is intended to show the part which the author has taken in the enunciation of that law.

MAGNETO AND DYNAMO-ELECTRIC MACHINES, WITH A DESCRIPTION OF ELECTRIC ACCUMULATORS. From the German of Glaser de Cew, by F. Kron, and specially edited, with many additions, by Paget Higgs, LL.D., D.Sc. (Specialists' Series, vol. i.) London: Symons and Co. 1884.

This work contains an historical account of the various magneto and dynamo-electric generators, and a description of the several parts of the different machines. A chapter is devoted to the physical laws bearing on the construction of electric generators, another on the employment of the generators for producing the electric light, and still another on the various uses to which the generators have been applied. The appendixes contain formulæ for the construction of electro-magnets, as well as descriptions for measurement, and of the latest construction of generators. The whole is completed by a very full index.

THE ART DESIGNER: a Quarterly Portfolio of full-sized Designs for Painting and Artistic Work. Vol. I., Parts 1-4. London: John Heywood. 1884-5.

This new magazine is devoted to the illustration of designs in all departments of the Fine Arts. The numbers contain designs for china painting, plaques, wood carving, art needlework, &c.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

MARCH 4.—"The Evolution of Machines." By Professor H. S. HELE SHAW. Sir FREDERICK BRAMWELL, F.R.S., Pres. Inst. C.E., Vice-President of the Society, will preside.

MARCH 11.—"Exploration, and the Best Outfit for such Work." By Major-General the Hon. W. FIELDING. FRANCIS GALTON, F.R.S., will preside.

MARCH 18.—"The Rivers Pollution Bill." By J. W. WILLIS-BUND. Capt. DOUGLAS GALTON, C.B., F.R.S., Vice-President of the Society, will preside.

MARCH 25.—"Introduction of the Beet Sugar Industry into England." By Colonel Sir FRANCIS BOLTON.

Papers for reading after Easter:—

"The History and Manufacture of Playing Cards." By GEORGE CLULOW.

"The Musical Scales of Various Nations." By A. J. ELLIS, B.A., F.R.S.

"A Marine Laboratory as a Means of Improving Sea Fisheries." Professor E. RAY LANKESTER, M.A., F.R.S.

"Recent Improvements in Coast Signals." By Sir J. N. DOUGLASS.

"The American Oil and Gas-fields." By Professor JAMES DEWAR, F.R.S.

INDIAN SECTION.

Friday evenings at Eight o'clock.

MARCH 6.—"The Trade between India and the East Coast of Africa." By FREDERIC HOLMWOOD, British Consul at Zanzibar. Major-General Sir FREDERICK J. GOLDSMID, K.C.S.I., C.B., will preside.

MARCH 13.—"The Present Condition and Future Prospects of Female Education in India." By MANCHERJEE M. BHOWNAGGREE, late Secretary of the Alexandra Girls' English Institution, Bombay.

APRIL 17.—"The Parsis and the Trade of Western India." By JEHANGEER DOSABHOY FRAMJEE.

MAY 8.—"The Ancient and Modern Methods of Treating Epidemics of Small-pox in India." By ROBERT PRINGLE, late Sanitary Department H.M. Bengal Army. Sir PHILIP CUNLIFFE-OWEN, K.C.M.G., C,B., C.I.E., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings at Eight o'clock.

MARCH 17.—"The Congo and the Conference, in reference to Commercial Geography." By Commander CAMERON, R.N., C.B.

MARCH 31.—"Kiliman'jaro and the Surrounding District of Equatorial Africa." By H. H. JOHNSTON.

APRIL 28.—"The Federation of the Empire." By J. E. GORST, M.P. The Right Hon. W. E. FORSTER, M.P., will preside.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings at Eight o'clock.

MARCH 12.—"Recent Improvements in Photographic Development." By W. K. BURTON.

APRIL 23.—"The Chemistry of Ensilage." By FREDERICK J. LLOYDD.

The dates given above are subject to alteration.

CANTOR LECTURES.

Monday Evenings at Eight o'clock.

The Fourth Course, "Chemistry of Pigments." By J. M. THOMSON, F.R.S.E., F.C.S., Lecturer on Chemistry at King's College, London.

LECTURE II. March 2.—Chemistry of Blue, Yellow and Red Mineral Pigments. Certain Organic Pigments. Special Pigments.

The Fifth Course, "Carving and Furniture." By J. HUNGERFORD POLLEN.

March 9, 16, 23, and 30.

The Sixth Course, "Photography and the Spectroscope." By Captain C. W. DE W. ABNEY, R.E., F.R.S.

April 20 and 27.

The Seventh and concluding Course, "The Manufacture of Toilet Soaps." By C. R. ALDER WRIGHT, D.Sc., F.R.S., F.C.S.

May 4, 11, and 18.

ADMISSION TO MEETINGS.

Members have the right of attending all the Society's meetings and lectures. Special tickets are required for the Juvenile Lectures. Every member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the members, but admission can also be obtained on the personal introduction of a member.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 2...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. J. M. Thomson, "The Chemistry of Pigments." (Lecture II.)

Farmers' Club, Inns of Court Hotel, Holborn, W.C., 4 p.m. Mr. Walter Gilbey, "Riding and Driving Horses, their Breeding and Rearing."

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, Westminster Town Hall, S.W., 7½ p.m. Mr. Arthur Rigg, "American Engineering Enterprise."

Chemical Industry (London Section), Burlington-house, W., 8 p.m. 1. Mr. W. J. Kemp, "Some Experiments upon that part of Mr. F. B. Rawes's Patent for the 'Recovery of Sulphur, &c.' which depends upon the Action of Carbon-dioxide upon Soda Waste suspended in a Liquid." 2. Mr. W. J. Williams, "The Treatment of certain Phosphatic Minerals."

British Architects, 9, Conduit-street, W., 8 p.m. Special General Meeting to elect Medallists, and to receive Report on Medals and Prizes.

Medical, 11, Chandos-street, W., 8½ p.m. Anniversary.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Mr. J. Hassell, "Was Primitive Man a Savage?"

London Institution, Finsbury-circus, E.C., 5 p.m. Archdeacon Farrar, "The Talmud and its Authors."

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8 p.m. Annual Meeting.

TUESDAY, MARCH 3 .. Royal Institution, Albemarle street, W., 3 p.m. Prof. Arthur Gamgee, "Digestion." (Lecture I.)

Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. Wm. Stroudley, "The Construction of Locomotive Engines, and some Results of their Working on the London, Brighton, and South Coast Railway."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m. 1. Mr. E. A. Walter Budge, "The History of the Coptic Martyr Isaac." 2. Mr. Edouard Naville, "The Inscription of the Destruction of Mankind on the Tomb of Rameses III.

Zoological, 11, Hanover square, W., 8½ p.m. 1. Mr. H. H. Johnston, "General Remarks on the Fauna of Kilimanjaro." 2. Mr. Charles O. Waterhouse, "The Insects collected on Kilimanjaro by Mr. H. H. Johnston." 3. Prof. F. Jeffrey Bell, "Note on a Nematoid Worm collected by Mr. Johnston on Kilimanjaro." 4. Mr. E. J. Miers, "Description of a new Variety of *Thelphusa* from Kilimanjaro."

College of Physicians, Pall-mall East, S.W., 5 p.m. (Gulstonian Lectures.) Dr. William Osler, "Endocarditis." (Lecture II.)

WEDNESDAY, MARCH 4...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Professor H. S. Hele Shaw, "The Evolution of Machines."

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m.

Entomological, 11, Chandos-street, W., 7 p.m.

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. E. J. L. Scott, "Early Manuscripts Relating to Tenby and its Locality." 2. Mr. H. Syer Cuming, "The Old Traders' Signs in Paternoster-row."

Obstetrical, 53, Berners-street, W., 8 p.m.

THURSDAY, MARCH 5...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Prof. Allman, "New Genera and Species of Hydroids from H. Gatty's Collection." 2. Rev. W. Colenso, "Recently Discovered Flowering Plants from Interior of New Zealand." Dr. F. Day, "Rearing. Growth, and Breeding of Salmon in Fresh Water in Great Britain."

London Institution, Finsbury-circus, E.C., 7 p.m. (Travers' Lecture). Mr. O'Connor Power, "A Commercial Code."

Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Mrs. Shiel, "Physiology and the Laws of Health." (Lecture II.).

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, "The New Chemistry." (Lecture VIII.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. (Special Meeting). Professor Unwin, "The Theory and Practice of Hydro-Mechanics." (Lecture III.) "Water Motors."

College of Physicians, Pall-mall East, S.W., 5 p.m. (Gulstonian Lectures.) Dr. William Osler, "Endocarditis." (Lecture III.)

FRIDAY, MARCH 6...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. Frederic Holmwood, "The Trade between India and the East Coast of Africa."

United Service Institution, Whitehall-yard, S.W., 3 p.m. Commander E. P. Gallwey, "The Use of Torpedoes in War."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Dr. C. T. Newton, "The German Discoveries at Pergamus."

Geologists' Association, University College, W.C., 8 p m.

Philological, University College, 8 p.m. Paper by the late Mr. C. B. Cayley, "Conditions of Onomatopoeia."

SATURDAY, MARCH 7...Royal Institution, Albemarle-street, W., 3 p.m. Mr. C. Armbruster, "The Life, Theory, and Works of Richard Wagner," with vocal and instrumental illustrations. (Lecture II.)

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FRIDAY, MARCH 6, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURE.

In his second lecture on the "Chemistry of Pigments," delivered on Monday evening, 2nd inst., Mr. J. M. Thomson dealt with certain points connected with the chemical changes produced in, and chemical composition of, red, green, and blue pigments. He showed how the purity of pigments might be tested, and an examination of the nature of the pigments made. The composition and properties of vermilion, red lead, and certain varieties of ochres were discussed among red pigments, and those of Scheele's green and chromium greens among the green pigments. Mr. Thomson then described the formation and constitution of Prussian blue, showing the different colours attending the different methods of formation of this body.

Finally, he described the general reactions dealing with the destruction of vegetable colouring materials, showing the destruction of certain of these colours by reduction or by oxidation. Specimens of colours, illustrating those spoken of in the lecture, were exhibited by Messrs. Winsor and Newton, and by Messrs. Reeves and Sons.

A cordial vote of thanks was accorded to the lecturer on the motion of the chairman (Mr. B. Francis Cobb).

The lectures will be printed in the *Journal* during the summer recess.

ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal for 1885, early in May next, and they therefore invite members of the Society to forward to the Secretary, on or before the 18th of April, the names of such men of high distinction as they may think worthy of this honour.

The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, or Commerce," and has been awarded as follows:—

In 1864, to Sir Rowland Hill, K.C.B., F.R.S "for his great service to Arts, Manufactures, Commerce, in the creation of the penny postage, and for his other reforms in the postal system of this country, the benefit of which have, however, not been confined to this country, but have extended over the civilised world."

In 1865, to his Imperial Majesty, Napoleon III. "for distinguished merit in promoting, in many ways, by his personal exertions, in the international progress of Arts, Manufactures, and Commerce, the proofs of which are afforded by his judicious patronage of Art, his enlightened commercial policy, and especially, by the abolition of passports in favour of British subjects."

In 1866, to Professor Faraday, D.C.L., F.R.S., for "discoveries in electricity, magnetism, and chemistry, which, in their relation to the industries of the world, have so largely promoted Arts, Manufactures, and Commerce."

In 1867, to Mr. (afterwards Sir) W. Fothergill Cooke and Professor (afterwards Sir) Charles Wheatstone, F.R.S., "in recognition of their joint labours in establishing the first electric telegraph."

In 1868, to Mr. (now Sir) Joseph Whitworth, LL.D., F.R.S., "for the invention and manufacture of instruments of measure and uniform standards, by which the production of machinery has been brought to a state of perfection hitherto unapproached, to the great advancement of Arts, Manufactures, and Commerce."

In 1869, to Baron Justus von Liebig, Associate of the Institute of France, For. Memb. R.S., Chevalier of the Legion of Honour, &c., "for his numerous valuable researches and writings, which have contributed most importantly to the development of food economy and agriculture, to the advancement of chemical science, and to the benefits derived from that science by Arts, Manufactures, and Commerce."

In 1870, to Ferdinand de Lesseps, "for services rendered to Arts, Manufactures, and Commerce, by the realisation of the Suez Canal."

In 1871, to Mr. (afterwards Sir) Henry Cole, K.C.B., "for his important services in promoting Arts, Manufactures, and Commerce, especially in aiding the establishment and development of Science and Art, and the South Kensington Museum."

In 1872, to Mr. (now Sir) Henry Bessemer, F.R.S., "for the eminent services rendered by him to Arts, Manufactures, and Commerce, in developing the manufacture of steel."

In 1873, to Michel Eugène Chevreul, For. Memb.

R.S., Member of the Institute of France, "for his chemical researches, especially in reference to saponification, dyeing, agriculture, and natural history, which, for more than half a century have exercised a wide influence on the industrial arts of the world."

In 1874, to Mr. (afterwards Sir) C. W. Siemens, D.C.L., F.R.S., "for his researches in connection with the laws of heat, and the practical applications of them to furnaces used in the Arts; and for his improvement in the manufacture of iron; and generally for the services rendered by him in connection with economisation of fuel in its various applications to Manufactures and the Arts."

In 1875, to Michel Chevalier, "the distinguished French statesman, who, by his writings and persistent exertions, extending over many years, has rendered essential service in promoting Arts, Manufactures, and Commerce."

In 1876, to Sir George B. Airy, K.C.B., F.R.S., Astronomer Royal, "for eminent services rendered to Commerce by his researches in nautical astronomy, and in magnetism, and by his improvements in the application of the mariner's compass to the navigation of iron ships."

In 1877, to Jean Baptiste Dumas, For. Memb. R.S., Member of the Institute of France, "the distinguished chemist, whose researches have exercised a very material influence on the advancement of the Industrial Arts."

In 1878, to Sir Wm. G. Armstrong, C.B., D.C.L., F.R.S., "because of his distinction as an engineer and as a scientific man, and because by the development of the transmission of power—hydraulically—due to his constant efforts, extending over many years, the manufactures of this country have been greatly aided, and mechanical power beneficially substituted for most laborious and injurious labour."

In 1879, to Sir William Thomson, LL.D., D.C.L., F.R.S., "on account of the signal services rendered to Arts, Manufactures, and Commerce, by his electrical researches, eepecially with reference to the transmission of telegraphic messages over ocean cables."

In 1880, to James Prescott Joule, LL.D., D.C.L., F.R.S., "for having established, after most laborious research, the true relation between heat, electricity, and mechanical work, thus affording to the engineer a sure guide in the application of science and industrial pursuits."

In 1881, to August Wilhelm Hofmann, M.D., LL.D., F.R.S., Professor of Chemistry in the University of Berlin, "for eminent services rendered to the Industrial Arts by his investigations in organic chemistry, and for his successful labours in promoting the cultivation of chemical education and research in England."

In 1882, to Louis Pasteur, Member of the Institute of France, For. Memb. R.S., "for his researches in connection with fermentation, the preservation of wines, and the propagation of zymotic diseases in silk worms and domestic animals, whereby the arts of wine-making, silk production, and agriculture, have been greatly benefited."

In 1883, to Sir Joseph Dalton Hooker, K.C.S.I. C.B., M.D., D.C.L., LL.D., F.R.S., "for the eminent services which, as a botanist and scientific traveller, and a Director of the National Botanical Department, he has rendered to the Arts, Manufactures, and Commerce, by promoting an accurate knowledge of the floras and economic vegetable products of the several colonies and dependencies of the Empire."

In 1884, to Captain James Buchanan Eads, "the distinguished American engineer, whose works have been of such great service in improving the water communications of North America, and have thereby rendered valuable aid to the commerce of the world."

Proceedings of the Society.

APPLIED CHEMISTRY & PHYSICS SECTION.

Thursday, February 26, 1885; Professor James Dewar, M.A., F.R.S., in the chair.

The paper read was on—

TEMPERED GLASS.

By Frederick Siemens.

The invention by M. De la Bastie of, so-called, toughened glass, which caused a great sensation at one time, induced the author of this paper to give close attention to the subject, which he proposes to bring before the Society on the present occasion. Being a glass manufacturer, there was every reason why he should interest himself in an invention which, entering the lists with great pretensions, claimed not only to revolutionise the glass trade as it then existed, but to supply a new material which should take the place both of glass and metals.

The author soon discovered that the De la Bastie process could lay no claim to the advantages to which it pretended, being indeed not a real manufacturing process at all, but rather a somewhat impracticable addition to known methods of glass-making. The wholly finished articles to be toughened had generally to be annealed in the first instance by one or other of the usual means, and thereafter to be heated to such a degree as to render them soft; they were

then immersed in a bath of heated oil, or other fluid, capable of being maintained at a temperature of from 350° to 400° Centigrade without evaporation.

The toughening of finished articles of glass in this way is not only a very costly addition to the original process of manufacture, but the articles themselves are very liable to have their shapes spoilt and their surfaces injured. But besides these objections, there is another important point to be considered, which is, the liability of toughened glass to burst suddenly into small fragments, either spontaneously or by a sudden shock, like the well-known Prince Rupert's drops, formed by dropping fluid glass into water, whose peculiarity of breaking up into powder has been generally supposed to be due to the sudden cooling of the soft or fluid glass. This theory is, however, only conditionally correct, inasmuch as the cooling influence which acts from the surface inwards is not in proportion to the bulk of the glass, but to its surface, and must always act more quickly on those parts where the surface is large in comparison with the volume. Even the simplest form—a sheet, for instance—cools more quickly at the edges than in the middle, owing to the large surface for cooling which the edges offer. If, however, the cooling is regulated so that at every instant of time the temperature of the article is uniform throughout, no internal tension or strain can arise, and there will consequently be no tendency to crack or break in the way described.

The author, having satisfied himself by a series of experiments of the true cause of the spontaneous fracture of glass, has invented processes of manufacture by means of which glass may be thoroughly toughened, or, as he prefers to call it, hardened. The principle upon which the processes depend consists in cooling the glass, not in proportion to its surface, but to its volume or capacity for heat. The method employed will be readily understood by considering a sheet of uniform thickness, which, after having been heated uniformly to a sufficient degree, must be cooled on the surfaces of its two parallel sides only, leaving the edges uncooled. This is done by placing the heated sheet of glass between two cold slabs of suitable material, prepared in a peculiar manner. Uniform cooling of the whole sheet is thus secured, no matter what its shape, because the edges are not subject to the cooling influence caused by the surfaces between which the glass is placed. The plan adopted for various articles varies with their shapes; but it is on the principle of uniform heating and cooling that the author's processes of manufacturing hard glass are based.

Of these, the two principal are known as press-hardening and casting; but, besides these, there is a third, theoretically less perfect than the others, viz., semi-hardening or hard-tempering; this, though less important may be advantageously employed, where presses would be unsuitable, and casting impossible or difficult, as in the case of bottles, lamp chimnies, &c.

Press-hardened glass has now been made, with constantly increasing success, for six years, at the author's Dresden Glass Works. The output has steadily increased more than 50 per cent. annually from £600 value in the first year, until last year it amounted to over £7,000, or more than ten times as much. As there is no indication of a diminution in the rate of increase, the author anticipates that the manufacture will assume large proportions. The articles are mainly of plate and sheet glass, either flat or bent into a variety of shapes. Besides plain work, decorated sheets, such as sign-boards with enamelled inscriptions, figures, and other ornaments, form an important part of the goods produced; the process, as already stated, is, therefore, one of manufacture (the goods receiving through it their definite shape and decoration), and not simply one of hardening or toughening. The glass is so hard that the diamond will not touch it, and it cannot, therefore, be cut or bent after manufacture; it may, however, be polished, etched, and slightly ground; its strength is at least eight times that of ordinary glass. As only absolutely homogeneous glass of the best quality is suitable for hardening, care must be taken in choosing sheet or plate-glass for this purpose, so that it may not be in any way faulty, or contain stones, bubbles, or other imperfections.

The process of manufacture is as follows:—The glass is first cut in the ordinary way to the requisite shape and dimensions, and is then exposed to the radiant heat of a peculiarly constructed furnace until quite soft; as soon as it has attained the necessary temperature, it is placed between cold metal plates, to be cooled down with a rapidity which varies with the thickness of the glass, but is in any case very great. The heating and cooling of sheet glass of ordinary thickness last altogether a minute and a half, a minute being the length of the

heating and half a minute that of the cooling operation.

It is a remarkable circumstance that glass may be thus heated and cooled in so short a space of time without either cracking or breaking; this is altogether due in the case of the operation of heating to the uniform temperature of the furnace, and to the heat being produced entirely by radiation; should these conditions not be fulfilled, the glass would break to a certainty. As regards the success of the cooling operation, this depends upon the uniform temperature of the glass before it is cooled, and upon that of the metal plates between which it is placed whilst being cooled. This uniformity of temperature, and the total absence of draught, which would cause irregular cooling, are the conditions under which the whole operation can be carried on with assured success.

It is most essential, as regards the good quality of the hardened glass, that the operations of both heating and cooling should be rapidly performed; it is also of paramount importance that the glass should be heated up to as high a degree as is compatible with its being removed from the furnace and placed between the presses, and one of the main difficulties in connection with the process was the arrangement of a proper mode of handling the heated glass, considering that it is almost in the molten state, and as pliable as a piece of cloth. The temperature to which the glass has to be heated is, therefore, far in excess of that of an ordinary annealing kiln, and it is owing to the high temperature employed that the glass can be bent and shaped, as also decorated and enamelled, during the process of hardening. In the ordinary process of enamelling, the glass can be exposed to a comparatively low temperature only, on account of its tendency to get out of shape. Retorts or muffles are generally used, and the temperature not exceeding that of an annealing kiln, the process of heating up is exceedingly slow, and the enamel to be fixed on the glass has to be of a very soft, easily fusible character; borax enamels are generally used, and even they cannot be properly melted so as to be thoroughly incorporated in the glass. The case is entirely different when glass is enamelled by the hardening process; the temperature employed being so much higher, and the heat acting so much more quickly, a more refractory enamel, such as that used for porcelain, becomes available. While in the first case the enamel can be scratched off the glass, and does not resist acids, or even the action of the atmosphere, the enamel on hardened glass is as indestructible as the glass itself. From this it will be evident, that the hardening is at the same time the most perfect enamelling process, and by far the cheapest, no extra heating operation being required.

It will now be readily understood that press-hardening is essentially a manufacturing process, the same operation which hardens the glass regulating the shape of the article, and fixing upon its surface a highly refractory and consequently superior enamel, admitting of variations of colour and design, practically unlimited.

It would lead the author too far were he to attempt to enter into all the details of the manufacture of press-hardened glass, which are very numerous indeed, on account of the variety of articles made; these are still on the increase, and there is no saying how long this may continue to be the case.

The surface of the metal plates, or moulds used for the presses, may be so prepared as to produce more or less cooling effect on the glass as required. If the glass is to be hardened to a very high degree, the metallic surfaces must be of very high heat-conducting power, such as copper, and must be left quite bare; the glass must also be raised to a very high temperature, as it would otherwise crack during cooling. If it is proposed to harden the glass to a lower degree, surfaces of iron are used, this metal not being so good a conductor of heat as copper, whilst the temperature of the glass is also kept lower. By covering the surfaces of the iron presses with wire gauze, their cooling effect may be reduced to any required extent, so that a certain amount of hardening may be produced without rendering it necessary to heat the glass to such a temperature as to make it difficult to handle, or to cause it to stick to the furnace bed. If a still lower degree of hardening is proposed, the faces of the presses may be covered with asbestos paper, or even clay slabs may be employed.

It is very essential to the success of the hardening operation, that the heating should be done quickly and by radiation only, otherwise the surface of the goods and their general appearance will be impaired. The bed of the heating furnace must be made very smooth, either by the use of clay, or of sandstone tiles, dusted over with talc powder, and should always be kept in perfectly good order; whenever it becomes uneven, or is otherwise

damaged, new tiles are placed on the old bed.

Semi-hardened glass is made in the same large radiation furnaces as press-hardened, by means of the hard-tempering process, of which the following is a description:—Finished articles, which are of a shape to which presses cannot be easily applied, such as bottles, are heated up to such a temperature as will permit of their retaining their form; each one is then placed in a casing of sheet iron, which is so arranged that the heated article shall not touch the inner sides of the casing. In order to effect this, the casing is provided with internal projecting ribs, which retain the glass article in position, touching it only at very few points. The casing with the heated article of glass within it is allowed to cool in the open air. Whenever it is a difficult matter to handle the heated glass, instead of placing it hot into the casing, the casing with the glass inside it is inserted in the heating furnace, for the requisite time, and then allowed to cool as before described.

The hard-tempering process is only applicable to articles of nearly uniform thickness throughout; bottles with thick bottoms, for instance, are not fit to undergo the treatment, as they would be apt to crack both during heating and cooling. The strength of semi-hardened is about three times that of ordinary glass, and it is not effected to the same degree as the latter by change of temperature; the process finds much favour as the constantly increasing orders sufficiently prove.

To secure success, a properly constructed heating furnace is of the utmost importance, as regards both processes. As already explained, it is necessary that there should be no draught within the furnace, that the heat should be uniform, and that the flame should not act directly upon the sheets or other articles of glass, which would be thus tarnished, and liable to break whilst being heated, or on cooling, if not heated uniformly. The furnace employed is the regenerative gas furnace, heated by radiation, which the author has lately introduced, with great advantage, for many industrial purposes, and fully described in a paper he read before the Iron and Steel Institute, in September last.

The third and last process to be described, which the author considers the most valuable of the three, is a peculiar mode of casting hard glass. This has not yet been introduced on a manufacturing scale, but the experimental castings produced have turned out to be quite satisfactory in every way. They consist of floor plates, grindstones, pulleys, tramway sleepers, and various ornamental work. The author thinks that castings might be produced, with advantage, for many other purposes, especially in connection with the building trades, but this can only be ascertained after works are established, which are now in course of construction, for the regular supply of goods manufactured by this process, as is already the case with the previously described processes. Glass may be cast in this way into a variety of forms, which it would be impossible to produce with ordinary glass, owing to the liability of the latter to crack whilst cooling; it has, moreover, at least four times the strength of common glass, and can be made much more cheaply.

It is manufactured in the following manner. Glass, melted in a tank furnace, such as described at the meeting of the Iron and Steel Institute, already referred to, is tapped into moulds, as with iron castings. The process thus far resembles that carried on in an iron foundry, but differs from it, inasmuch as a special material is used in place of sand, and that the mould and the glass inside it are heated and cooled together.

The material or mixture to be used in place of sand must be selected so as to have, as nearly as possible, the same conductivity and capacity for heat as glass; in such a case, the glass and mould forming, as it were, one homogeneous body, the glass will cool without cracking, even if the cooling process is comparatively quick, which is quite necessary if hard glass is to be produced. Glass cast in this way may have almost any variety of form and inequality of thickness, in the last respect this process differing entirely from those previously described, in which only glass of uniform thickness can be dealt with. If care be taken that the surface of the glass does not approach the outer casing of the mould, it does not much matter how the cooling is effected. The great point is that the mould and glass should be brought to a uniformly high temperature, which should be rather above that at which press-hardened glass is made. When fully heated, the mould is taken from the furnace and allowed to cool in the open air, which generally acts quickly enough to produce a good hardening effect upon the glass within. When cold, the mould is opened, and the glass removed.

It will be readily understood, from the descriptions given, that the three processes differ

so materially from one another, that hardly any resemblance remains to show that they are merely different ways of treating differently shaped articles, in carrying out the principle of keeping the whole body of the glass at a uniform temperature during the operations of heating and cooling.

The De la Bastie process, as well as the ordinary tempering processes employed, fail in not being founded on the principle set forth; glass toughened by the De la Bastie process being cooled in a fluid bath, and ordinary glass in kilns, the cooling action is most active on the portions offering the largest surfaces to the cooling influence, and hence in the one case there is a strong tension or strain in the molecules, which causes them to break up spontaneously; and in the other case, to counteract that tendency, it is necessary that the glass should be cooled very slowly.

In all cooling operations the principle developed in the paper ought to be the ideal aimed at, and the author is convinced that ultimately every kind of glass will be more or less hardened in the cooling process; there is no reason why this should be done quickly, it may be done slowly, so as to allow of the glass being cut and ground while still possessing increased resisting power, and having less tendency to break under the influence of change of temperature. In the future, hardened glass will bear the same relation to ordinary glass that steel now bears to iron. It will, of course, be a long time before this result is brought about, just as it has taken a long time to develop the use of steel to such an extent as almost to have replaced iron in the market.

As a proof of the extent to which the production of hardened articles of glass has been already developed, the author has placed some samples of hardened glass on the table. The members of the Society of Arts will thus be in a position to judge for themselves as to the comparative value of this glass, as well as of its strength and immunity from temperature influences. In the collection is included samples of military water bottles, of which more than 10,000 have already been supplied, mostly to volunteer regiments in this country, and glass similar to that used for fitting up the chart-room on board H.M.S. *Inflexible*, which was ordered after a report of trials made on board of H.M.S. *Glatton*, where the tempered glass withstood the concussion of the firing of heavy guns.

From the steady progress in the past, there is every reason to believe that in future the hardening processes described in this paper will be applied to all manufactures of glass of an important character.

Several experiments were made at the conclusion of the paper, to show the strength of the tempered glass; pieces of ordinary sheet glass and of the tempered glass being placed on four corks, and a cricket ball dropped upon them from various heights. The ordinary glass broke with a fall of about 2 feet; whilst, in some cases, the tempered glass did not break except with a blow from a height of 5 feet 4 inches.

DISCUSSION.

Mr. E. A. Cowper said great thanks were due to Mr. Siemens for bringing forward this new manufacture in a practical form, but it was not a new thing, nor a small matter, seeing that the business had risen to £7,000 a year in six years. Several of the drinking bottles he had seen for some years past, and they were very much liked because they were clean; tea could be put in them one day and beer another. The question of cutting with a diamond was a very curious one. You could scratch the surface of some of these sheets, but you could not cut it; it would not split through as common glass did. Probably that was due to common glass being in a state of tension, which, when relieved by a scratch, caused the glass to fly right through; so that even plate-glass, half an inch thick, would succumb to the slightest scratch of a diamond one-hundredth of an inch deep. With this glass you could not do that. The castings would be an important new manufacture. The tempering was not so thoroughly carried out in this case as in the hardening of glass in other forms, but it was sufficiently hard to serve as sleepers for tramways and railway chairs for electric railways. He thought also architects would welcome this as a means of obtaining articles of various tints, whereas they at present had to search for different stones. By this process they could obtain them, to any extent, in various tints, and in any form, by casting. Something of the same sort was attempted some years ago by Mr. Attwood, who used basalt, which was cast at Chance's factory in Birmingham. He made some heavy castings for mantel-pieces and so on, but it was a complete failure, as there was no means of hardening or probably annealing them. Some flew to pieces. One of the defects of the De la Bastie process was that the articles sometimes suddenly burst into little bits, the reason of which no doubt was that, being dipped into a liquid, one part necessarily got cool before another. If you wished to set up various strains by producing various temperatures at the same instant of time, there you had the process in perfection, for it was impossible to dip a glass article even into oil at a high temperature without chilling it in such a way as to produce varying strains. The cooling surfaces Mr. Siemens used

were, first, a large plate of iron on which the glass was quickly laid, and then the top plate came suddenly down upon it, and it was squeezed perfectly flat, so that every part was in contact with the iron. If it were merely laid on a sheet of iron, the glass might cockle a little, and the proper effect would not be produced. Various experiments would be necessary to give the exact comparative strength, and he should have liked particularly to see experiments on the actual tension by pieces being put into a hydraulic press and pulled apart. It was evident this product was very much liked in Germany, and some day, no doubt, it would be equally popular in England.

Mr. LUDWIG MOND said he had been much struck by the difficulties which Mr. Siemens had so successfully overcome in this manufacture. As he and his lamented brother had been the originators of processes which had wrought such great changes in our art industries, it was quite certain that, in undertaking this question, Mr. Frederick Siemens would solve it successfully, although it had baffled the efforts of others. He regretted that Mr. Siemens had not given some description of the furnace he used. As a chemist, he might remark that, when the question of glass turned up, it was found to be now practically the same substance chemically that it was at the time of the Phœnicians. He certainly thought it would repay the chemist to attack the question from the chemical point of view, and see what could be done, not by mechanical processes—by heating and cooling—but by attempting to produce new chemical compounds which should possess the qualities desired.

Mr. J. HEAD then drew attention to the various specimens exhibited, particularly to the ornamental glass, which was ornamented and tempered at the same time. Another useful application of this process was in enamelled plates with names and addresses for streets, &c., which might be made very strong and cheap. A sample of this kind was not on the table, but one was being made bearing the name and address of the Society, which would be presented to it. Amongst the other specimens, he drew particular attention to a large casting in the shape of a tuning fork, which was very resonant on being struck.

Mr. SIEMENS remarked that that shape could not be produced at all in ordinary glass in a mould, as it would be sure to crack. It could only be produced by pouring it into a mould formed of material having the same heat-conducting power.

Mr. R. W. WALLACE referred to some experiments he had tried some months ago with the De la Bastie process, with the result that in almost every instance, with a less blow than had been shown to-night, the object had suddenly cracked, and the appearance of the fractured glass was altogether different; it broke into a great many pieces, and when you examined the fracture, it was evident that the cooling was done in an altogether different manner. The structure seemed to be quite amorphous, and it broke up into a condition like sand. He had had some experience of these drinking bottles, for two years ago they were served out to the Inns of Court Volunteers, who took them to Brighton on one occasion, and to Portsmouth on another. During the whole time he only saw one broken, although they were subject to very rough usage, such as knocking the butt end of rifles against them, and throwing them about the floors of the barrack rooms, every effort being made by the volunteers to try and show that they were no better than those they had had before. In the end, however, they gave unbounded satisfaction to every one who used them. He hoped to hear something of the applicability of this glass for chemical experiments. Some years ago he tried some experiments with retorts toughened by the De la Bastie process, but they were not successful. Glass could be used in the manufacture of sulphuric acid, but only in one process; you could not manufacture the acid continuously. If you brought the heat up gradually and allowed it to cool gradually, you could concentrate sulphuric acid in a glass retort; but if you tried to do it continuously, the retort cracked immediately. With a De la Bastie glass retort he got a slightly better result than with ordinary glass, but not a successful one, and he should like to hear whether any attempts had been made in that direction with this glass. Of course he could see there would be a difficulty in getting the annealing surface on the inside of the retort, but perhaps that might be met by making the retort wider at the top. All who were interested in these matters owed a great deal to the firm of Siemens for the energy and skill with which they had attacked these problems. Some day, perhaps, they might have bells made of glass.

Mr. P. F. NURSEY said about ten years ago toughened glass by the De la Bastie process was brought under his special notice. He was requested by some friends to investigate and report upon it, and for that purpose he went to the factory near Paris and saw the process, which was heating the glass and plunging it immediately into hot oil. It was singular that long before De la Bastie worked out that process, he attempted the very means which Mr. Siemens had adopted, but without success, for he attempted pressure, adopting the idea from Sir Joseph Whitworth's process. He had had the honour of reading a paper in that room on the subject, and perhaps some were present who witnessed the experiments on that occasion. To his mind, those shown that evening did not compare with those which he then showed. He might say that, when he visited M. De la Bastie's factory, he tried an experiment with a number of champagne tumblers which were placed edgeways on a shelf. He fired at them with a saloon rifle at twelve paces; several

times he knocked them off their perch, and one obstinate one he knocked off twelve times in succession, and only broke it at the thirteenth shot. It was a very severe test. In order to ascertain what the real strength of the material was, he carried out a series of tests in conjunction with Mr. Kirkcaldy, and their report was made on the 18th May, 1875. There were ten pieces of tempered and ten of untempered glass of various lengths, 12 to 15 inches, and 4 inches broad, and all the same thickness, about ·265 in. They were placed on supports giving a bearing of 5 inches, a block of wrought iron being cut out to make a pan beneath. Under each edge were laid strips of india-rubber, and on the top was placed another piece of rubber, and on that pressure was brought from a knife edge, in some instances by a gradually increasing weight; in others the strips were placed in a testing machine, and the knife edge brought on them horizontally. The mean result was that the ordinary glass stood 206·2 pounds; the tempered glass 828·1. Mr. Cowper had referred to the desirability of having tensile tests made, and he hoped he would carry that wish out, but he believed it would puzzle his ingenuity, as it did his own and Mr. Kirkcaldy's, for they could not get the glass to be held by any known means; they could not get a bite on the glass. With regard to the tests made by Mr. Wallace, he did not think the material could have been properly tempered. In some instances, glass articles made by English manufacturers did not come out so well as those made by De la Bastie himself. Having quoted from the report in the Society's *Journal* the account of his own experiments, he added that on that occasion one gentleman dropped a plate of the glass on an iron hearth at a distance of from 1 foot up to 5 feet without breaking it. He did not deny that Mr. Siemens had improved on this process as far as ornamentation went, but he did not think De la Bastie had attempted anything of that kind, though his glass could be ground by the sand-glass process. He had some tumblers at home, beautifully engraved with his monogram, which had been in use for ten years. The process had now dropped into abeyance, but recently he understood it was being brought out by another company.

Professor GRYLLS ADAMS, F.R.S., said he was very much interested in seeing experiments with regard to the breaking strain of glass, and one could judge at once by comparison of the heights the amount of energy actually spent on the glass. In one case dropping a ball less than 2 feet broke the ordinary glass, whilst it went up to 5·4 to break the tempered glass, and taking the comparison between the two, it would give an estimate of the actual energy spent on the glass. Of course, it was of great importance, in performing such experiments, that they should be exactly under the same conditions, and these could only be taken as a rough proof that one was much stronger than the other, and it was hard to judge what the actual strength would be. He was much interested in the strength of glass, principally from an electric point of view.

Mr. D. CHADWICK said he was disappointed at not seeing any toughened glass experimented on, to show the relative strength of that and Mr. Siemens's. He could endorse all that Mr. Nursey had said about the De la Bastie glass, which he had experimented on over and over again, and he felt certain it would stand greater violence than that which had been shown that evening. Mr. Cowper had spoken of the way in which that glass was cooled, which caused it sometimes to explode spontaneously, and no doubt ten years ago that did occur, but as now made, such a thing was so rare that practically it did not apply at all.

Mr. McLAUCHLAN asked if any attempts had been made to make this glass into tubes, and also what was the cost as compared with other materials.

Mr. R. M. LAWES also asked the relative cost of manufacture by this process. The other day, on purchasing some toughened glass, he found it was nearly double the price of ordinary glass. If this were as dear as that, it would not be likely to come into general use.

Mr. J. STONE said he remembered attending the meeting when the De la Bastie glass was introduced, and it was then stated that slabs of glass for roofing purposes, if they cracked at all, cracked immediately into thousands of pieces, which of course was dangerous for workmen, but he noticed that this glass did not break at all in that manner.

Mr. FREDERICK SIEMENS said his process and that of De la Bastie could scarcely be compared, because the latter was merely a toughening process, whilst his was one of manufacture, by means of which he shaped and hardened the glass in a single operation, either by means of presses, or casting into moulds, and in a new manner. The De la Bastie process was only an additional operation, applied after the article was finished, to toughen it; but even for that purpose it was wrong, inasmuch as the cooling influence acted in proportion to the surface, whereas it ought to act in proportion to the bulk of the glass. Those parts which exposed much surface to the cooling influence, cooled more quickly than those of less surface, and, consequently, there would be unequal cooling which should be avoided. At each unit of time the whole article should be at one temperature, and that could only be effected by regulating its temperature according to its capacity for heat. If one part was cooled more quickly than another, there was a strain which could never be removed. For that reason, the process of cooling in a bath was wrong; whilst the slow cooling applied to ornamental glass was expensive. By the ordinary mode, many articles which he had shown could not

be produced at all, even if cooled ever so slowly, for they would have very little strength, and the least accident would cause them to break. Toughened glass was apt to break spontaneously, owing to the tension set up during the process of toughening; generally speaking, if it did not break very soon, it would last a long time; but its liability to break was the reason it was expensive. He had omitted many points of detail from the paper for the sake of brevity, but he described three different processes, in each of which there were many peculiarities. He had already described the construction of the furnace at the Iron and Steel Institute, and a great deal depended upon it, not only as regarded the success, but also the economy of the operation. [Mr. Siemens drew a rough sketch on the board to show the kind of furnace he used, in which the flame was shown to pass over the top of the furnace without touching the articles, radiating the heat down upon them.] On the bed of the furnace were tiles on which the articles were placed. The flame was about three feet from the glass, which caused a uniform heat, and prevented injury to the articles themselves and to the bed of the furnace. The articles were removed with wooden shovels, impregnated with water glass so as to render them incombustible, and they were then placed upon a cool metal plate, upon which another was pressed down. He had only brought forward manufactured articles such as were sent out to be used; the bottles would stand four times the ordinary wear and tear, and the sheets eight to ten times. He arrived at this conclusion from the circumstance that the breakages of the street lamps of Dresden and Berlin were now only about one-tenth what they used to be, and only cost one-tenth for repairs. He could have prepared glass which would stand very much more strain than that tested; he might have selected pieces which had stood the test already; but those shown had been taken quite at random. Sometimes a piece would break at five feet, though it had already stood the test at ten feet, or it might be dropped on the ground several times without injury, and eventually break, the difference of result depending entirely upon how the glass was struck. Bottles and hollow articles were the most difficult to harden; the sheets and hard castings were the most perfect, but hollow articles could not be made very well in the way in which those were made. Pipes might be cast, moulding them somewhat as iron pipes were; but it would require a little ingenuity. The strength of an article could be increased by heating it to a higher temperature, and cooling it more rapidly, but there was a certain limit when the manufacture became unsafe; and for commercial purposes, it was necessary to avoid losses through breakages, which would make the articles expensive. With regard to the price, it differed very much, some articles were very cheap indeed; it did not cost more to glaze a street lamp with tempered than with ordinary glass, but then the glass was supplied in sheets ready cut to the exact size, and the expense of the glazier's time in cutting the glass, and the loss thereby occasioned was saved; but it could only be introduced for that purpose as corporations of towns came to have lamps or window panes of a uniform size. Decorative glass was produced more cheaply by this process, because the ordinary mode of decorating was by an additional process which was very expensive; the glass having to be heated in a muffle slowly, besides which the heat used to burn in the designs and inscriptions was not high enough to fix them well. There was hardly any limit to the designs which could be produced in this way; anything that could be done on porcelain could be done on this glass, and it could be done more cheaply. It would be useful for signboards of houses or shops, but there must be an establishment near the place where the glass is to be used, as it would not pay to send single sheets from Dresden to London. With regard to the hard castings, he had not had so much experience, because they had not yet regular manufacturing establishments, and had hitherto only manufactured them experimentally, whereas real knowledge on such subjects was only to be attained by practical working. The hard-casting process, although it had not yet been brought out commercially, was, in his opinion, of the utmost importance, as it was an entirely new process, by means of which glass might be made in any shape which could be moulded, and of a strength which could not otherwise be produced. The material employed for moulding was certainly dearer than the moulding sand used for castings of iron. This was due to the circumstance that it must not only be suitable for moulding, but had to be, when moulded, of the same conductivity and specific heat as glass. He was still making experiments, so as to obtain the most suitable material for this purpose, but had found various mixtures of powdered porcelain and glass pots, metal turnings and filings, and such minerals as heavy spar and magnetic iron ore, to be suitable when mixed in certain proportions. On the whole, these materials were not dear, and, as regarded the labour and expense of moulding, it would probably be about the same for castings of glass as of iron. As a manufacturer, he looked upon cost as a most important matter for consideration, as, however good a thing might be, it was of no value commercially unless cheap enough to find buyers. As regarded the hard-cast glass, he could produce a hundredweight of castings for about 5s. 6d., which should be cheap enough for any purpose for which it was proposed to be used. He was now erecting a factory which would be at work in a couple of months' time, and, later on, he should be pleased to give the Society further information on the subject. He felt quite satisfied that orders would come in, for his hard-glass castings supplied a want which was felt on all sides. Glass was not liable to oxidation, or to wear away, and as soon as it could be depended upon for strength, and could be made cheaply, it would be applied for purposes for which metals

stone; and porcelain had hitherto been used. If a factory were established in London, he believed a great trade would spring up.

Mr. WALLACE asked if slag could be utilised.

Mr. SIEMENS said it depended largely on what the slag consisted of, for this varied very much. The only advantage would be in running it direct from the blast furnace, so that it need not be re-melted, whilst there was the disadvantage that it contained no alkali.

Mr. HEAD remarked, that considering these articles were only one-third the density of iron, and cost 5s. per cwt., they would be really very much cheaper.

In reply to the CHAIRMAN,

Mr. SIEMENS said one physical property in which this glass was different from other glass, was that it stood changes of temperature better. It might be a little more elastic, but it was not tough, only hard.

The CHAIRMAN said that specimens of the De la Bastie glass which he had seen in the field of the polariscope at once revealed enormous strains; he should like to know if this glass showed anything of the same kind.

Mr. SIEMENS said it showed something, but not much.

Professor ADAMS said he should like to have the opportunity of testing this glass in that way. There was no question that the toughened glass was very much under strain, because the usual figures of unannealed glass depending on the shape of the glass were very clearly marked.

Mr. SIEMENS said if they could ever come to such perfection as to cool actually in the ideal way, that appearance would be taken away. Some pieces showed it more than others.

The CHAIRMAN said this was a most interesting communication in every respect, and fully worthy of the Siemens family. They always found in the papers of Mr. Siemens and his brother that they began on some perfectly definite basis to achieve a particular result. Anyone attacking this problem for the first time would hardly have thought of trying industrially to eliminate from any given surface of glass a quantity of heat which should be perfectly uniform and definite; and that achieving that, you might do it at as rapid a rate as you could attain to. In fact, he understood that the more rapid the more successful it would be, provided it was uniform. Here the scientific problem was to withdraw a certain number of units of heat quite uniformly, and at a uniform rate, from each side of a piece of glass, so that the old idea that the only way to reach uniformity in a plastic solid of complex nature like silicate, by slow cooling, and allowing the molecules to gradually attain their normal state of want of strain, might be achieved practically instantaneously if done in a proper way. It was really a most remarkable result, not only in itself, but from the applications it was likely to open up in the future. Nothing succeeded like success, and the figures given as to the demand for this manufacture were sufficient proofs of its usefulness. He concluded by proposing a cordial vote of thanks to Mr. Siemens for his admirable paper, which was carried unanimously.

THIRTEENTH ORDINARY MEETING.

Wednesday, March 4, 1885; Sir FREDERICK BRAMWELL, F.R.S., Pres. Inst.C.E., and Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Allin, Samuel Sealy, 52, Woodstock-road, Bedford-park, Chiswick.
Angus, John, 47, Lime-street, E.C.
Collum, Rev. Hugh Roberts, The Vicarage, Leigh, Tonbridge, and Junior Athenæum Club, W.
Hutchinson, C. C., 28, Windsor-road, Forest-gate, Essex.
Norman, Simeon, London-road, Burgess-hill, Sussex.
Russell, John, 16, Marloes-road, Kensington, W.
Sanderson, Thomas Crisp, 31, Hatcham-park-road, New Cross, S.E.
Schloesser, Frank, 10, Sutherland-avenue, W.
Stone, Thomas William, 17, Davisville-road, Shepherd's-bush, W.

The following candidates were balloted for and duly elected members of the Society:—

Craik, George Lillie, 29, Bedford-street, Covent-garden, W.C.
Johnson, Charles (Messrs. Llewellyn and James), Bristol.
McCabe, H. Bernard, 45, Friday-street, E.C., and King's Langley, Herts.
Morris, Frank, Gasworks, Brentford.
Muir, James, Staunton Harold, Branksome-park, Bournemouth.
Obicini, George W., 109, Adelaide-road, N.W.
Platt, James, Rookwood, Hampstead, N.W.
Reynolds, Donald Fraser, 42, Charterhouse-square, E.C.
Symons, Simon, Belfort-house, Farquhar-road, Upper Norwood, S.E.
Williams, Thomas Henry, 5, Gloucester-road, South Kensington, S.W.

The paper read was—

THE EVOLUTION OF MACHINES.

BY PROF. H. S. HELE SHAW.

If we look back through the history of man, we find that his progress in civilisation stands in close relation to, and, in fact, is measured by

his power over the material world around him. When we examine the means by which this power is obtained, it becomes evident that it is limited to the physical operation of changing the relative position of the materials at his disposal. At first, man was content to accomplish his purposes in order to obtain food, or for self defence, with such materials as he found in their natural state; but when a certain measure of progress had been made, and the struggle for a bare existence became less severe, he began to realise the advantages of a previous arrangement before the actual operation in view, and evidenced the possession of intellectual faculties by the design and construction of tools rather than by the mere use of them. It was the power to give materials definite form, and to effect combinations with which desired operations could be performed, that enabled further progress to be made, and so, from step to step, flint implements replacing those of bone, bronze and the easily worked metals those of flint, culminating at length in the employment of iron, the most difficult to work, but most valuable of all; man advanced slowly at first, but after a while at an increased rate, towards the present mighty achievement in the industrial arts, the comprehension of only a small portion of which now demands the study of a lifetime.

For a long period man, to supply all his wants, used only such simple appliances as would, without hesitation, be called implements or tools. Gradually, however, attempts were made with ever increasing success to obtain the desired result with less labour and more certainty, by the construction of what might, even in their simple state, be truly called machines. Bearing in mind man's only physical mode of producing any change in the world around him, it is not hard to understand why the great extension of power and capability of making further progress may be traced to the development of machines. The relation of machine development to civilisation is a subject of the greatest interest, but of vast range, and scarcely less extensive is the history of machine development itself; but they might be well brought directly, as they have so often been indirectly, before this Society, which was founded for the encouragement of Arts, Manufactures, and Commerce. Neither of these, however, form the direct object of this paper, but one which it has been said the Society has ever steadily kept in view, viz., "the application of science to practical purposes." In order to study the application of science to the development of machines, the past must be examined, so that the course of development may be seen; and though it is obviously impossible to follow in detail the growth of machinery, a few examples may be selected which will be sufficient to illustrate the fact that the growth has taken place on certain well defined principles. It will afterwards be possible to see more clearly what is the present state of this branch of science, not only with reference to the other sciences, but also to the practical requirements of future machine development.

The history of the early machines is lost in antiquity, but it has been shown that there are strong grounds for considering the fire drill or twirling stick, first revolved between the hands of one or two operators, as one of the earliest examples of machinal motion, and that a long period must have elapsed before the introduction of continuous, instead of alternating, rotary motion. It is extremely probable that the first continuous motion was employed in connection with the grinding of corn. The use of a simple stone to pound the wheat was followed by the use of the pestle and mortar; which, as Beckmann, in his "History of Inventions," has remarked, was probably the kind of mill possessed by every family; which Moses forbade to be taken in pawn as being, for obvious reasons, the same thing as to take a man's life in pledge. This early mill was first worked by a female slave, then by bondsmen, and afterwards by cattle; and though at first, no doubt, only a heavy kind of pestle was used, it became evident that the end would be better and sooner accomplished if the flat cylindrical stone, with a vertical spindle, were employed, and thus arose a true example of a machine. It is evidently necessary at this point that as clear an idea as possible should be obtained of what constitutes a machine, and, therefore, without attempting to add another to the many definitions already existing, we may consider a machine to be a combination of materials arranged by man, so as to enable determinate motions to be obtained. Possibly, long before the corn mill had been advanced to the form which might entitle it to be regarded as a machine, there were many simple machines for other purposes, such as for drawing water, preparing clothing, and for agricultural purposes. These were actuated by the muscular effort of men or animals; and though the employment of the latter evinced considerable progress, it was a far greater and more important step when the

forces of nature, other than muscular, were first turned to do work in machines. No doubt the power of flowing water was the first so used, though whether for irrigation or with corn mills, or for any other purpose, it is impossible to say. Beckmann considers that corn mills were first introduced in the time of Mithridates, Julius Cæsar, and Cicero, and states that a floating mill was employed by Belisarius on the Tiber, in the year 536; but the Chinese used water-wheels for the purposes of irrigation at a very early date. The use of the more uncertain and refractory element, wind, for motive power, showed a still further advance, and though difficult to fix the exact date of the first windmill, it has been shown by Beckmann that it is very improbable that the Romans knew of them, as the first authentic record does not occur in the classics, but in the account of a mill in France, as late as the year 1105, one in this country being mentioned in the year 1143. The greatest difficulties of all had to be overcome in bringing into direct application the molecular forces to actuate machines, but at the same time this step has been by far the most productive of results. The invention of the steam-engine may truly be said to mark a new era of progress, for it has given to man the direction of almost unbounded, and at the same time perfectly controllable, machine power. On account of its importance, and also because its history is better known than that of most other machines, no better example could be chosen to illustrate the manner of machine development.

The first proposal to use the expansive force of steam was made by Hero of Alexandria, more than 2,000 years ago, but for several hundred years after, not even a reference appears to have been made to the subject. At length, however, with the revival of learning, attention was directed to the properties of steam by one philosopher and another. In the 16th century, Cardan mentions the vacuum formed by the condensation of steam; and there are on record the suggestions, more or less vague, of Matthesius, Besson, Ramelli, Leonardi da Vinci, Porta, Solomon de Caus, Branca, Wilkins, and others, all belonging to what Professor Thurston, referring to the steam-engine, has called the age of speculation; but the time was not ripe for practical results, and neither knowledge of scientific principles nor of the use of materials was sufficiently advanced to enable an application on more than the smallest scale, and in more than a tentative manner, to be made of these proposals. It is not till about two centuries ago that the period of application is reached; and then we find that science had progressed, the art of working iron was well established, and many machines existed. The inventor who then took up the subject, and carried it to a point far beyond what it had hitherto reached, was the second Marquis of Worcester, who, in addition to the advantages already mentioned, which time and workers in other directions had brought him, possessed both wealth and influence, and was a thoughtful and studious man. This nobleman set to work upon the problem, which he prosecuted with the greatest ardour to the end of his life, and of the ultimate success of which he entertained the most exalted opinions. Yet, in spite of all this, he died poor and unsuccessful. His "water-commanding" engine, as he called his steam pump, was neither yet demanded with sufficient emphasis, nor was the practice of working materials yet sufficiently advanced to make his trial at Raglan Castle, and, later still, at Vauxhall, in London, more than a partial success. Still the problem of steam power was thus brought prominently forward, and Sir Samuel Morland published, soon after, a table of volumes and corresponding pressures of steam, which, considering the date (1683), was a remarkably close approach to the best results hitherto attained. Time went on, and the miners in Cornwall were suffering from the water in their shafts; so again, in the west of England, we find another inventor working at the question of steam. This inventor, Thomas Savery, of Devonshire, was also an educated man, being a military engineer, and it is probable that he was well acquainted with the work of the Marquis of Worcester. This is to be inferred, not only from certain statements published at the time, but from the fact that his engine bears considerable resemblance to that of Worcester, at any rate as far as can be made out from the marks on the walls at Raglan Castle, and the mystified description of it which was published. Now it must be borne in mind that both these engines applied the expansive force of steam treated of by Hero, with the principle of condensation mentioned by Cardan, for forcing water in the way suggested by Porta and Solomon de Caus, but had increased the complexity of the apparatus proposed by De Caus, but the addition of a separate vessel in which the forcing was performed, and by sundry valves which, however, greatly increased the efficiency of the engine, and in fact rendered it a prac-

ticable machine. Savery's engine worked to a certain extent satisfactorily, but a limit to its powers was soon reached, simply from the imperfect materials at his command. This is made clear from the comically serious account of Desaguliers of the expenses Mr. Savery was at because he had to use hard solder instead of soft, as the latter would not withstand the heat or pressure at the joints of the boilers. It is a significant fact that one of the most successful of recent inventions, viz., the Pulsometer, is nothing more than an automatic Savery engine, which would be as useless as the engine of Savery, were it not for the present increased knowledge of the nature and properties of materials. To Denys Papin, a distinguished Frenchman, belongs the honour of suggesting, in 1690, the use of the cylinder and piston, with which the pressure of the atmosphere could be utilised when the steam was condensed inside. That he afterwards went back from this, and endeavoured to use the inferior design of Savery, in order to obtain continuous motive power by raising water for a water wheel, does not, as it has been asserted, testify to ignorance of its superiority, and cause him to forfeit the credit for its invention. He himself said that "the principal difficulty is that of making these large cylinders," and his attempt to overcome this difficulty is proved by the present existence of a large cylinder of his construction in a court of the museum at Cassel, in Germany. The next inventor moved forward a great step, and this step was the practical application of the steam cylinder of Papin. Here, again, the west of England, where previous inventors had worked, and where the steam engine was urgently needed, supplied the inventor, in the person of Thomas Newcomen, blacksmith and ironmonger, of Dartmouth, who was assisted by John Cawley, a glazier. The former living but 15 miles from Savery, was probably well acquainted with his work, even if he had not been actually employed upon a portion of it, and had certainly the advantage of knowing Papin's proposal, as is evidenced by his correspondence with Dr. Hooke. The engine, under Newcomen, now assumed the form of a train of mechanism more complex, but far more efficient, and, down to a certain limit, the pits were cleared of water. An accident led to the use of internal injection, and consequent increase of power in the engine. The ingenuity of a youthful attendant some time after led to its conversion into a self-acting motor, which only occurred when the boy, Humphrey Potter, to save himself the trouble of working the valves by hand, devised an arrangement of strings and catches to perform this operation automatically. Beighton replaced the latter arrangement by a beam with sundry levers and tappets, and Smeaton still further improved, enlarged, and at the same time complicated the engine. It was, however, to James Watt that the greatest advance was due. This inventor began his study of the subject in 1763, at the point to which it had brought by previous inventors, as he was led to examine the defects of the steam-engine from a model of that of Newcomen, at the Glasgow University. His first and greatest contribution to the problem was the separate condenser; but it is only possible to sum up all his work, and it may be said that Watt found the steam-engine single acting, and merely capable of exerting a force in one direction. He left it double acting, capable of giving continuous rotary motion, self-regulated, vastly more economical and reliable. To attain all this, he, however, had to invent and apply much more complicated valve arrangements, packing for glands, parallel motion, governors, separate condenser, hot-well air-pump, crank, or its substitute, the sun and planet motion, and fly-wheel, not to mention a great number of mechanical details, such as extra bearings, connections, &c., for carrying these additions into effect, and for constraining the motion of the various parts, so as to make the action more certain and reliable. In reading the life of Watt, it is evident that his greatest difficulties were not in conceiving ideas but in executing them, and that the struggle to find material and workmen represent largely his efforts during the interval of twenty years which elapsed before success rewarded his efforts. It is now just 100 years ago since Watt took out the patent for his rotative engine; and, excepting in one or two points, no improvement which has resulted in simplification can be said to have taken place. Improved machine tools have enabled the more complex parallel motion to be replaced by the guide bars, and crosshead of the ordinary horizontal or vertical engine; but if the condenser is often for practical reasons removed, this necessitates a loss of efficiency as a heat engine. On the other hand, neatness of design must not be mistaken for simplification of parts, and the compact and apparently simple modern engine may yet have reversing gear expansion valves, automatic lubricators, and a variety of appliances, which render it really more complex than the old beam engine

of Watt. But to obtain an idea of the direction which progress has really taken, take the case of the engines of a first-class Atlantic steamer. The details in the annexed table of the number of parts of such have been furnished to the author through the courtesy of the builders.

Table showing the Number of Parts in the Engines and Boilers of a First-class Atlantic Steamer.

Jam nuts	238
Split pins	400
Levers	37
Guard rings	108
Pins	1,144
Moving parts	100
Total number of pieces in engine	6,000
Auxiliary engines	23
Steam pipes	271
Pumping-out arrangement	172
Valves	147
Gauges	9
Lubricators, impermeators	147
Bolts	7,868
Studs	3,000
Nuts	10,407
Rivets	64,888
Boiler tubes	2,270
Condenser tubes	4,456
Boiler stays	1,582
Furnace bars	1,356
Furnaces	24

Perhaps one of the most significant items is that of the twenty-three auxiliary engines, each a separate self-regulating, self-contained, motor, supplied simply to work separate portions which, at first, used to be worked by the main engines or by hand. Consider the 764 parts made up of jam nuts, split pins, and guard rings, placed solely for extra security, not to say the 1,144 pins, many of which are for this purpose; and lastly, the enormous total of which appear to amount to 104,642 parts, each requiring separate construction, fitting, and securing, and, truly, it will be said that progress does not take place in the direction of simplicity. But if the visitor is led to turn from the difficulty of even understanding this complex system, to the thought of what a marvellous achievement the design of such a machine must be, perhaps, what strikes him even more than its complexity is the perfect interdependence of the parts, and the extraordinary ease with which it is all controlled, and, in short, the wonderful unity of the machine as a whole.

The progress of the invention of the most important class of machines, viz., prime movers, has now been briefly traced, and it will be found that there are certain salient features in their development common to that of all machines.

The first of these seems to be that progress does not, as a rule, take place in the direction of simplification, but rather from simple to complex forms, accompanied by more definite, reliable, and constrained machinal motions. In proportion as the machine becomes capable of performing more extended operations, and accomplishing them by itself, requiring less human intervention—that is, becomes more automatic and self-regulating—so the parts multiply, and complexity increases. This Professor Kennedy, in his translation of Reuleaux's work, has called an extensive and intensive growth; extensive, in decreased range of operations; and intensive, in increased internal power of action. This tendency is certainly that which is visible in past progress; and this replacing of manual effort and intervention still goes on, and is, for instance, illustrated by the enormous increase in the number of small auxiliary motors.

In the next place, it is seen that there is a conspicuous dependence upon the growth of the other arts and sciences, especially upon the knowledge of the use of materials. Again, it is clear that machines are not the product of one man's brain, but of the successive labours of many minds, and are a growth rather than a sudden creation. That this is true, even of ideas, is illustrated by the fact that nearly every successful inventor in the case of the steam-engine seems to have had the benefit of knowing not only the successful, but often also the unsuccessful, attempts of previous workers, and to have even then required considerable time and labour to project further advance.

In addition to these points, there is another which comes out more clearly when a study of the lives of the inventors themselves is made, and this is that the course of invention has not been by any means continuous, but that often even a retrogade movement has taken place. Machines have not only been unsuccessful because proper materials have not been forthcoming, but also because attempts at improvement have been made upon wrong principles. A striking example of this is furnished by the immense number of unsuccessful attempts to make a rotary steam-engine, towards which end inventors have been (and are) apparently urged by false views of the

value of simplicity in a machine. This is not only a procedure in a false direction, on purely machinal grounds which have been explained and exposed by Reuleax, but also appears to be opposed on certain general principles to the best method of employing steam as a working agent, and the only rotary engine which at present promises to be a success has elaborate arrangements for packing purposes, rendering it anything but simple in construction.

The truth of the foregoing conclusions becomes increasingly evident upon a review of the history of other machines, whether for weapons or tools, for preparing food or clothing, for the purposes of measurement, or the communication of ideas. Only one example in each of these important classes of machines can be referred to, and that only in a word or two.

Of weapons, the most important is the firearm, and of this the forerunner is seen in the cross-bow, which replaced, with more perfect guiding arrangements, the simple bow and arrow. The elastic force of the bow string was, after long use, replaced by that of the heated gases from the exploded powder; but the old matchlock was, as its name implies, a crude weapon compared with the flintlock, and the latter was vastly more simple than the musket with percussion cap; then came the early Enfield rifle, followed by the breechloading Snider and Martini, each more complex than its predecessor, but still simple compared with the Gatling, the earliest machine gun, which was first brought forward during the American war; this was followed by the Hotchkiss, the Lowell, the Nordenfelt, and Gardner. It was reserved for Mr. Hiram Maxim, of London, to conceive and quite recently to carry into execution, a weapon which is a marvel of automatic action, and illustrates, in a remarkable manner, a tendency towards that intensive development of machines already referred to. This gun actually performs all the functions of carrying the cartridge to its place, of locking it in, cocking, firing, withdrawing the shell of the cartridge, and ejecting it, and this not by the force of human action, but simply by the force of its own recoil, which has only hitherto produced an injurious shock upon the supporting frame. Yet the external appearance of this gun is remarkably simple, and it has but one barrel; but if anyone thinks its construction is really a step in the direction of simplicity, let them go through the process of understanding its action from written description, aided merely with diagrams. Yet in the history of guns, the progress has not been always in the forward direction; the big breechloading guns first introduced were, after awhile, discarded, and a return made to muzzle loaders; but this was simply because of the difficulties of safe and reliable construction, a matter which the progress of knowledge has in time enabled to be satisfactorily accomplished.

In the case of tools, the early hand tools preceded the primitive lathe, in which, when two operators were not required, the two hands of the worker were supplemented by the assistance of one foot, his big toe being also brought into requisition as he sat on the ground in front of his work. The lathe, with a simple hand rest, was the factotum of the early machinist; by its means his boring, turning, and drilling was at first done, but by degrees the slide rest and screw-cutting gear, speed cones and surfacing arrangements, pulleys, and various other appliances, were gradually introdueed. The increased complexity is not only seen in the particular machine in question, but in the variety of special tools derived from it, such as meet the eye of the visitor in vast array in such a place as, for instance, the machine department of the locomotive works at Swindon. There are seen special turning, boring, surfacing, drilling, screwing, facing, polishing, grinding, centering, and other machines, all to do the special work of the early lathe, and of many of these numerous varieties exist, often differing considerably in external appearance. These are only a small portion of metal-working machines, and equally striking examples of tools for working wood and other materials might be taken. Special tools like the steam hammer have a history which testify to the nature and mode of progress, not less than the lives of Maudslay, Whitworth, Nasmyth, and other great tool makers. The progress of the hammer, from the first stone weapon to the tilt hammer, and then to the great step of the steam hammer by Nasmyth, which no one would take up in this country even after its application, at first unknown to him, at the Creusot Works in France, because "it was not likely to be required," its improvement by Condie, and the limit of its powers, not by any inability to construct still larger forms, but for reasons which render hydraulic pressure upon huge masses of metal a superior kind of action, all of this being in accordance with the views previously stated.

In connection with machines for supplying

and preparing food, there might be taken the whole class of agricultural machinery, besides a large number of special machines for various purposes. The early history of corn mills has already been referred to, and in the gradually increasing number of appliances which were introduced into the water mill, increasing to a certain extent with the introduction of the windmill, and in a still greater degree with the modern steam flour mill might be found undeniable increase of complexity. But if the system of low grinding with the simple circular stone has itself grown more complex, what might be said of the system of high grinding (invented to deal with the hard grains) as practised in Austria and America, where the flour is, by a complex series of mechanical processes, divided into as many as ten or twelve different qualities, or of the various refinements for cleaning and separating the grain for grinding, for sifting or dressing, and lastly for purifying. A high authority on the subject, Mr. Proctor Baker, says, "One rule must predominate over all other considerations, viz., that the material in the process of manufacture must not require to be moved by hand labour, at any stage, from its reception into the mill until it is finally packed in the bags in which it is to be delivered to the consumer." But in this case many millers have found to their cost that there is a very close connection between the machine and the work required from it, and that costly and expensive plant does not ensure the best results, if the correct requirements of the case are overlooked. The tendency is to make the process more independent of external intervention from manual sources.

Coming now to the important class of machinery employed in connection with clothing, the history of machines for working either cotton, wool, hemp, or flax, all tell the same tale of gradual improvement and more intensive forms of construction; but instead of any of these, which have really become systems of machines, a single machine of more modern introduction may be taken. The sewing machine is universally known and employed, and is commonly supposed to have been invented, perfected, and brought into general use almost at once.

This is, however, very far from the case, and a writer in Knight's "Dictionary of Mechanics" thus describes its invention:—

"The earliest machine first used the needle and needleful of thread in making a running stitch. Then the eye was placed in the middle of the needle, which was sharpened at both ends, to save turning it about when returning it, the needle being pushed and drawn by steel fingers on each side of the goods. The invention was yet an implicit copying of human manipulation, and the next step merely shifted the mode from the stitch of the seamstress to that of the tambour worker. The needle was passed through the goods and returned, leaving a loop, which was to be detained so as to be entered by the needle at its next descent, leaving another loop, and so on. A modification is mentioned of a crotchet hook; . . . . but a man of mark will find a new departure. He must devise new modes of procedure adapted to the needs of the new steel man, who is automatic but unskilful, and one of whose principal requirements is continuity of motion. . . . . The new elements were not invented all at once. One of the most important was overlooked for fifty years after it had been patented. Another was invented, made, and exhibited, and then slept a profound sleep of twelve years; another was invented and patented, but was in a useless shape, and lay dormant until really valuable inventions were made, when it arose and claimed them as mere adaptations. There is no important machine for sewing fabrics now manufactured that does not use all of the three elements mentioned—the continuous thread, the eye-pointed needle, and the continuous feed; but the former two of these had been in existence for sixty and twenty years respectively before they were united to the latter, which, coming in the fruition of time, was more quickly recognised as a necessity."

Yet, curiously enough, this clear account is prefaced by the following words:—

"The growth of invention is in the direction of simplicity; but it is necessary, in the first place, to conceive needs, and then to follow a host of temporary expedients—mere patchwork, as it afterwards appears. In the course of time rises a reorganiser, who proposes to devise means adequate to meet the changed conditions which supervene, when a machine is called upon to take the place of the human operator."

Now, from what was before quoted, it is clear that the sewing machine really became more complete in proportion as it became more efficient; and indeed, the last lines show that the writer, to a certain extent, recognises this fact; so that this is an evident case of the common error of confusing the idea of apparent simplicity from improved external design, with the real simplicity of essential parts.

Time does not permit of any account to be given of the growth of that typical instrument of measurement, the clock, even one stage of which, viz., the invention of the chronometer by John Harrison, the history of which has

been recently so ably told by Dr. Smiles in his "Inventions and Industry," is so full of instruction. Neither can machines for the communication of ideas be more than briefly noticed by a reference to the also typical printing machine. Blocks of burnt clay, stone, and wood, had been used from the earliest times, and from the handles upon those in the British Museum, which were in use by the Romans before the Christian era, the mode of operation is evident. It is not very clear when the first printing press was invented, but the early screw press was evidently in use for a long time prior to the year 1620, when Blaew, of Amsterdam, introduced the travelling bed, the lever-screw for depressing the platten, and the spring for raising it. Only slight modifications were made until the invention by Lord Stanhope, at the end of the 18th century, of the toggle joint press. In 1790, Nicholson invented the first cylinder machine; in 1811, Koenig (whose history is also so well told by Dr. Smiles) set the first steam-printing press to work, and the *Times* of November the 29th, 1814, was the first instance of a newspaper printed by steam. The course of invention has since then moved onwards, and anyone who has watched an edition of the *Times* being printed off will be quite prepared to admit with, perhaps, as much emphasis, the marvellous definiteness and certainty of action of the present machine, and they will also admit the fact that simplicity is not the most striking and obvious feature.

The foregoing examples will suffice to make it clear that machine development has followed the path of progress from simplicity to complexity, and at the same time from indefiniteness and uncertainty of results to definiteness and certainty; also that this has been accompanied by the tendency to multiply different special parts, or even separate special machines, as in a machine workshop or mill, but, at the same time, to render the machine or machine system more and more one compact and integral whole. But this is exactly following what is known as the law of evolution. This law, long ago applied by Herbert Spencer in his first principles to social progress generally, is defined by him thus—"*Evolution is a change from an indefinite incoherent homogeneity to a definite coherent heterogeneity, through continuous differentiations and integrations.*" Perhaps the thought may occur to someone present that evolution might with profit hold with regard to this mode of statement of the law itself, but it is evident that its application to machines is fully justified. But the law is borne out in details, notably by the fact that progress, as has been shown in several cases, has not been continuous and uninterrupted, for that some time a retrograde movement has taken place, and sometimes the environment, in other words the state of other arts and sciences, has required modification for any further change at all to be made. Thus again may be applied to machine development Herbert Spencer's statement in reference to progress generally, that "throughout that rearrangement of parts which constitutes evolution, we must nowhere expect to see the change from one position to another affected by continuous movement in the same direction. We shall everywhere find a periodicity of action and re-action, backward and forward motion, of which progress is a differential result." Hence there appears to be abundant grounds for taking, as the expression of an important truth, the idea conveyed by the title "The Evolution of Machines."

All that has been hitherto done in this paper is to consider the actual growth of the machine itself, and the ideas which have guided inventors have been only alluded to incidentally. It is, however, the latter subject, viz., the line of thought followed by the inventor, which really forms the object of our investigation, and to which the study of the growth of machines was only a preliminary but necessary step.

The points concerning the inventor which appear to have been brought out, are:—

1. The increasing complexity of the machines which it is his task to improve upon, and the already highly developed state in which he finds them. This fact necessitates careful preliminary study of the subject if—as was, for instance, the case of James Watt—he would start level with the age in which he lives, and from that stage of development to which other workers had brought the problem he essays to carry to a still more complete solution.

2. The successful inventor is not, as a rule, the entirely original genius commonly supposed, but has depended upon others for many suggestions and experimental results.

3. That however sound may be the ideas of an inventor, he depends both upon the progress of the other arts for its successful carrying out, and upon the demands of the age for its successful introduction and application.

It will be well to consider briefly the modes of thought and procedure of inventors, and without

pretending to do more than mention typical cases, it may be said that there is, first, the man who, knowing little of what has previously been done, upon conceiving an idea, at once endeavours to put it into a practical form with such rude materials as he may be able to command, and after many failures, even supposing that he succeeds, probably finds that his idea is either of no practical value or has been invented many times before. Next there is the man who, with little experience or knowledge of principles, yet has the wisdom to spend time in a vigorous preliminary effort to ascertain what has already been done, and the effort will need to be vigorous if we search the Patent - office accords in their present state; but even though ill-equipped with appliances, he at any rate starts with a knowledge of previous attempts, and does not waste time in re-invention. Lastly, there is the man who, either trained in science, or, what in the present case amounts to the same thing, has correct views of the principles which concern his end, starts with a full knowledge of the special machine, as far as it has hitherto been developed, and who has command, either by means of good workmen or by his own personal knowledge and skill, of the best appliances of the existing state of the arts. Though it has been said that great inventors are born and not made, yet, however naturally gifted the inventor of the first class may be, it will take a long and weary struggle to give him anything like a chance of doing what one of the last class may at once accomplish. In spite, however, of this, it will be found that the difference between these inventors, however great it may appear, is really one of degree, and that the general mode by which the result has been arrived at is, as far as it can be discovered, practically the same. Though the last may have used one or more known sciences, it was, to a certain extent, by a process unknown to himself that even he arrived at the result. It was more or less a groping in the dark—in one case it was almost all darkness—but on some of the steps in the other the light of knowledge was flashed. Thus, as Reuleaux has pointed out, there arises that reverence for the inventor which is greatly due to the fact that he has succeeded by a process which is unintelligible even to himself. And what has been said of inventors generally may, with equal truth, be said of the every day practice in a drawing office, of designing machines even with only slight variation to previous forms. But this is clearly not science but art, the art partly natural, partly acquired, of putting together knowledge, and of applying the results of science. It may, therefore, not unnaturally be asked—Why is not a distinct science of machines directly applied to the problem to be solved?

In order to answer this question, let us briefly glance at the history of the study of machines, and particularly at its present state. It was not to be expected that a science of machines would be originated before machines had themselves reached a certain stage of development; but that after it had been originated it would itself follow, as other sciences have done, the law of evolution. Such has been the case with the study of machines, which at first was merely descriptive; but as machines multiplied, some classification became necessary, and attempts were made to effect this. Reuleaux, in his sketch of science, considers Leupold to be the first to separate (in 1724) single mechanisms, but that nothing like a system was formed until quite the end of the 18th century; he proceeds to review the various attempts to found a science of machines upon fundamental principles, but it must here suffice to say that though each worker has taken a part in the progress of science, yet no one succeeded in founding a system which has had a practical application, and we therefore come at once to the system of Professor Reuleaux himself.

Rather more than ten years ago, the "Theoretische Kinematik" of Reuleaux was published in Germany, and about two years after was translated into English, and edited by Professor A. B. W. Kennedy, who, for excellent reasons, adopted for it the title of "The Kinematics of Machinery." The kinematics of machinery may be considered as the science of the motion of constrained bodies, regarded specially from the machinal point of view. Bearing in mind what was said at the commencement of the lecture, no arguments are needed to show why this must, to a great extent, be regarded as the science of machines; for it is clear that if the only physical mode of operation by which man can act is to effect a change in the relative position of matter, this not only shows, as there explained, the reason of the importance of machines, but also points to the science of machine motions as the branch of greatest importance. This it does by making it evident that the object of a machine is to effect a desired definite movement or motion of some portion of matter. The practical bearing of this consideration is forcibly illustrated by Reuleaux's ultimate division of all machinal

arrangements into place-changing machines, as, for instance, locomotives, cranes, clocks, &c.; and form-changing machines, as, for instance, corn-rolling—or saw-mills, lathes, paper-bag machines, &c.

The deep and far-reaching principle upon which the system of Reuleaux is based, is that of the mutual contact of the moving parts of a machine. In all cases these parts must have the property of mutual envelopment, if their relative motion is to be constrained and definite; and this correspondence or pairing, which is an essential feature of the machine, leads to the statement that a machine consists solely of bodies which thus correspond pair-wise reciprocally. Pairs join together links, and links form a chain, and a chain is a machine. It is by the combination of chains that any and every machine, no matter how complex, is formed. This method of viewing the machine problem leads to a matter of the greatest importance, viz., the construction of a "notation" for machines upon scientific principles. Previous attempts to introduce symbolic representation of machine parts had only been partially successful, even for trains of wheelwork, while for general purposes they had been eminently unsatisfactory. The value of Reuleaux's system is shown by the concise way in which it represents the remarkable results of his analysis of machines, and puts the otherwise impossible task of understanding at any rate the leading features of all the various machines, within measureable distance of being grasped by the human intellect. But more than this is done. After analysing a large number of machines, Reuleaux concludes by what must be regarded as the first effort to found a system of kinematic synthesis, or building-up of machines. The problem of kinematic synthesis is divided by him into direct and indirect, each of these divisions being again subdivided into general and special. General direct synthesis should give immediately the mechanisms to effect a given place or form change; but it is shown, from practical reasons, that useful results from this cannot be expected. Special direct synthesis would furnish a pair of elements suited to effect the above result, but neither can this method give results of practical value.

General indirect synthesis should give beforehand the solution of all machine kinematic problems in advance. This is obviously an enormous requirement; but it is shown that there are six principal chains or mechanisms upon which most machines are based, and these Reuleaux examined. Special indirect synthesis, however, does lead to really practical results, and the whole possible number of pairs are determined and arranged in twenty-one orders. The author of this system does not, however, recommend the special study of this branch of the subject, but rather that machines should be treated under applied kinematics generally, and arranged according to their practical application. Indeed, beautiful and interesting as this part of the subject is, it must be said that it appears to be the least satisfactory portion of Reuleaux's great work, and this, with our present object in view, is certainly disappointing. Perhaps the reason for this is to be found in the fact that the motion to be obtained, though it truly forms the practical object he sought, and therefore makes the branch of the subject already considered the most important, can, after all, only be carried into actual operation by practical means. In short, the definite and constrained motions sought after can only be obtained by employing suitable materials of the necessary strength. The progress of knowledge concerning materials has already been shown to have always borne an intimate relation to the progress of machines, and obviously upon the scientific application of this knowledge must further advance depend. Reuleaux, it is true, introduces the idea not merely of rigid solid bodies and flexible solid bodies (as belts, cords, &c.), as Willis had done, but also fully considers, from a kinematic point of view, the machinal properties of liquids and gases, and one of the most important and interesting parts of his work deals with this subject. This is a great advance, but still there is an immense field untouched by this system, as, for instance, the nature of the best forms to be given to the links, or, most important still, the actual effects from the contact between different materials, the nature of which very often entirely decides the fate of a new machine. On these points our knowledge is yet far from complete. Thus take the modification of the time-honoured laws of friction when applied to lubricants, resulting from the recent experiments by the Committee of the Institution of Mechanical Engineers, or consider how much is even now known of rolling friction, and its exact effect on frictional contact. Knowledge of materials is increasing with the increasing use of testing machines of all kinds, but unless the unlikely event happens

of very great discoveries in the preparation of materials continuing to be made, some more compact and final arrangement of the present knowledge in connection with the science of machine development should be possible. In addition to mere motion and the question of materials, the scientific application of the principles upon which the forces of nature can be made to overcome the resistance to the required motions in the machine, have also frequently to be considered by the inventor. These three branches of knowledge now considered, viz., motion in machines, the nature and strength of materials, and the forces which are required, are studied in this country under the heads of Mechanism, Machine Design, and Prime Movers, and collectively represent the present state of the science of machines. It must, therefore, be admitted that at present no definite synthetical science exists which can be directly applied to the "evolution of machines."

When the difficulties in the way of such a science are realised, it may, perhaps, be doubted if its ultimate evolution be possible. Such a doubt might, not many years ago, have been well felt about chemistry, and what chemist would have been led by the highest flight of imagination to anticipate a tithe of the results which have ensued from the introduction of chemical notation, applied to carefully collected facts. Organic chemistry, before that event, had not an existence, and, to say nothing of inorganic chemistry, what human brain could carry all the facts necessary for further investigation, if a dercriptive notation did not render classification upon scientfiic principles possible? But, beyond this, the most important results have been in the direction of synthesis; and no one would venture to assert that the building-up of such complex bodies as indigo, benzene, or even of acetic acid, would in all probability ever have been made without the aid of a scientific notation. A complete synthetical science of machines appears, however, to present, in some respects, greater difficulties than even those in the corresponding branch of chemistry. Without attempting to institute too close a comparison, it may be said that in the latter, the object in view is the building-up of a body, of which the parts are known by analysis, but not their grouping or arrangement; the nature of these groups, and the mode of re-forming them, have to be determined by careful reasoning and experiment. In the machine problem, a result has to be obtained, the necessary parts required for which, as well as their grouping or arrangement, have to be determined. And this we have, in addition to mere synthesis—the selection and determination of these parts in the form of pairs and links, as well as their combination into definite groups or arrangements, in order to form complete chains, or series of chains, necessary for the constitution of the complete machine. But, beyond even this, there is the selection and preparation of suitable materials with which to construct these parts, and this has been shown to form in itself a matter of no little importance. In spite of these difficulties, there appears to be no reason why, at any rate, a great advance should not be made on the present methods of machine evolution, for it must be pointed out that, in one respect, the machine problem is vastly more simple than the chemical, in that we can combine at will machine parts, and understand their mode of combination; whereas we have no certain physical conception of the nature of the molecular combinations which result in the production of such different external forms. Even in its present state, however, much might be done by a more systematic teaching in this country of the science of machines as it at present exists. At this point, however, the vast results already attained in the direction of machine development may occur to you, and at the same time, the nature of the methods—or, rather, want of methods—of previous workers; and the doubt may arise as to the need of such an arduous search for a more scientific treatment of the question, and such a careful preliminary study of the subject. It will, therefore, be well, in conclusion, to briefly consider this question.

The respectful admiration with which a successful inventor is regarded has been already alluded to, and one, indeed perhaps the chief reason, has been mentioned; but there is another, and perhaps equally significant one, which is that the lot of the large majority of inventors is simply failure. The statistics of the Patent-office furnish striking testimony to the testimony of this. The diagram on the wall represents the curves obtained by plotting the number of applications in each year for patents, since the important act of 1852. The years are given along the horizontal scale, and the number of patents applied for and proceeded with for 3, 7, and 14 years, are shown by the corresponding height on the vertical scale, so as to give the different curves. The curves are partly taken from the Commissioners'

Report of 1880, and filled in, as far as possible, up to the present date from data kindly supplied by Mr. Lloyd Wise. The point to be first observed is the large number of applications not proceeded with, and the great drop in the number carried on after three years, lastly, how small a portion survive the seven years' period. Now, the greater number of these patents are for machines or mechanical devices, and it may be asked, why all this failure? which, however, large as it is, only illustrates a small proportion of the non-success of workers at new and improved machines. Some small portion of it is, no doubt, due to want of funds to carry on the work, but chiefly it arises from either a discovery of want of novelty, or of impracticabillity in successful execution of working, or of improved methods of carrying the idea into operation; that is to say, from (1) ignorance of previous achievements, (2) or of principles, (3) or of practical details.

1. Every day makes it harder to keep abreast with the multiplication of machines; thus take one book, and that not the largest on the subject, viz., Knight's "Dictionary of Mechanics," in which are nearly 4,000 pages, and 10,000 engravings of inventions which are, or have been, in actual use, but this does not represent a tithe of those essayed and found to fail. Nearly a century ago, Beckmann, writing of the invention of a machine for sowing seed, remarked, "The case with Laua (the inventor) was the same as with many ingenious men who possess great powers of invention, as they never read but only think, they are unacquainted with what others have done before them, and therefore consider every idea which comes into their minds as a new one;" and thus, as Sir John Hawkshaw, in his address as President of the British Association, remarked, "Many a patient investigator has puzzled his brain in trying to solve a problem which had yielded to a more fortunate labourer in the field some centuries before." But if Beckmann's saying had force in his day, when the number of machines was so few, what should be the reading necessary at the present time? The truth is, that in the present state of the literature of the subject, the reading necessary to determine what has been previously done, in the case of any one special class of machines, or very often of a single machine, is well nigh appalling, and any one, for instance, who had attempted a weary search among the patent records, would testify to the urgent need of a more scientific treatment and classification. The work of indexing at present being carried on in our Patent-office will prove a great boon to inventors, but a great deal more might result if that classification could be made on really fundamental principles, such as have been proposed and fruitfully applied by Reuleaux.

2. Ignorance of principles is another cause of failure. Correct principles are not by any means of necessity intuitively grasped, an instance of which fact is given in the case of George Stephenson, than whom a clearer-headed man or better mechanic, perhaps, never lived, but who, at one period of his life, spent no little time in the attempt to make a perpetual motion machine. Even those principles which, as the result of long experience, have been handed down in the form of apparently simple laws, require long and careful study for their realisation. How often does an inventor, possessed by one idea, go round and round in a circle, in the endeavour to carry it into practice, and, like a mouse in a cage, return, after a cycle of attempts, to the original designs, sometimes quite unconscious of the fact, and sometimes with a faint hope that he has not yet tried it in quite the correct way. This may lead, and sometimes does lead, to discovery and a successful invention, but is far more often the mere pursuit after an *ignis fatuus* in the shape of an impracticable scheme. A better acquaintance with principles might prevent this, and it needs no argument to prove the advantage to the inventor of being able to clearly realise the main principles upon which he intends to construct a machine, such as the employment of a given chain, and the mere variations in the mode of carrying it out by the alteration, such as by inversion or expansion, of certain pairs of elements of which it is formed.

3. Again, there is an ignorance of practical details, as, for instance, of the most suitable materials and mode of employing them. The inventor on these points often calls to his aid the practical man, and, if his idea is correct in principle, he may thus be enabled to carry it into execution. But there is an unsatisfactory aspect to even this course, for it may be that the principle, though correct in itself, requires for its successful carrying out conditions which the so-called practical man is not very likely to realise, at any rate at first. This is in fact the important subject of the limits imposed by the materials available, and this becomes in itself a scientific question. Take as an example the case of heat-engines. In the case of the hot-air engine, it may be

said that precisely the same chief difficulties exist at the present day which led to the rejection of the Stirling engine some time after its trial in 1845, at the Dundee Foundry. The limit of power was due to the limit at which the vessels could be heated; yet, up to the present time, inventors continue to try and increase the power of this, in many respects, admirable motor, by different small and minor alterations, and yet have only at their command, and so can only employ, the same materials as were used forty years ago. The late lamented Chairman of the Council of this Society expressed, some three years ago, as his opinion, that the gas-engine was in the same condition as was the steam-engine at the time of Newcomen, and that the necessary cooling of the cylinder caused a loss of from one-half to two-thirds of the total heat generated; but at present this heat still continues to be thrown away, notwithstanding the labours of innumerable inventors, simply because of the working limit of temperature with the available materials in use. To this cause also must be traced the comparatively small increase in the efficiency of the steam-engine since the time of Watt. But while, on one hand, the fact has to be clearly realised by inventors that the limits of temperature, strength, and the velocities of surface contact are known and have to be reached, yet the possibilities opened to them by an advance, such as the employment of the electric current or of the use of steel, affords fresh ground for further study and advance. The comprehension, therefore, of what is practicable and what is not becomes of the highest importance.

Enough has been said to show that a more careful treatment of the whole science of machines would be justified from the point of view of the individual inventor. The great advance in scientific instruction in the country, notably under the auspices of the Science and Art Department, but also in school and colleges, has prepared the way for this. But still it is not to be expected that all inventors will, in the future, be at the pains to acquire the information of real value to them, or even in some cases be more patient of salutary advice than formerly, from the outsider who sees the reason of the futile attempt to escape from the cage of a leading idea. Here, however, a law which has special application to biological development holds rigidly, both with respect to machines and their inventors, and a process of natural selection assuredly results in the survival of the fittest.

There are other grounds for asserting that machine science should be carried to a more complete state, and that it shonld be more applied than at present, and these, did time permit, might be profitably discussed. Thus it may be found that, just as from the International Exhibition of 1851 we had to realise the unpleasant fact of Continental superiority in the production of many machines, and were led to make the great changes of the Patent-law of 1852, so in the forthcoming International Exhibition it may be made clear that the more systematic and long continued instruction in machine science abroad has led to results which may stimulate its more careful treatment in this country. Or, again, much might be said about the present basis and grounds of the examination of patents in the Patent-office. From the curves of applications for patents already shown, it is evident that though the number has been steadily rising since 1852, yet an extraordinary increase has taken place since 1st January last year, when the new Patent-law came into force, and up to the present date the number promises to be nearly as great for this year. There is little doubt but that this is greatly owing to the reduction in fees during the earlier stages, though it remains to be seen what proportion will be carried through the periods of seven and fourteen years, for which the fees remain the same. It may, however, be safely predicted that this great rise will contain even a smaller proportion of surviving patents, and it will be admitted that Sir Frederick Bramwell had good grounds for not wishing the fees to be so reduced as to lead to an abnormal increase of ill-considered schemes. It is certain that, even at present, the difficulty of deciding whether an invention is new will be much increased, and will continue to increase, unless some more scientific mode is adopted of determining what really constitutes novelty in an invention. The evils of the present want of a universally recognised scientific basis of examination is even more strongly felt in applications for patents in various foreign countries, as many a luckless patentee knows to his cost.

To sum up the results in this paper. An attempt has been made to show that machine development has followed a definite course, and has obeyed the general law of progress; that the science of machines is likewise following this law, but at present must be regarded as in an inchoate stage; that there are strong grounds for its increased study and application in this country, and, at the same time, for its further development.

In conclusion, it may be said, the growth of knowledge generally has resulted in laws which have not only brought the numberless facts within our grasp, but have led to further progress. We may not agree with Buckle in his fundamental principle as applied to the history of civilisation, which is, that "the totality of human actions is governed by the totality of human knowledge;" but we must admit that the totality of human inventions is so governed. Thus we feel that, in this case, the words of Hermann Kopp, in speaking of the science of chemistry, and quoted by Professor Schorlemmer, apply with force :—

"The alchemists worked in vain; it is not in our power to appropriate to ourselves the experiences and results which the future alone can bring. But in a certain sense we are indeed enabled to prolong our life backwards into the past, by appropriating the experiences of those who were before us, and by becoming acquainted with their views as thoroughly as if we had been their contemporaries. The means of doing this is also an elixir of life."

Thus in yet one more respect we have a feature of evolution apparent. Biologists tell us that each animal lives in one short life the whole course of development of its species. So must the inventor live through the whole progress of the special machine he seeks to improve. He may do this by repeating the painful experiences of former workers, or he may avail himself of those lessons which their failures and successes have taught. We should think strangely of a would-be explorer who refused to reach the real scene of his labours by the track which, imperfect and toilsome though it might be, had, in its mere discovery, cost the life labour of many previous travellers; and who, neglecting to avail himself of the previous experience of others, preferred to fight his way to the same end through thicket and jungle. We should scarcely expect him to ever attain that point where his real labours should commence. This must we think, too, of the inventor who, slighting the history of the past, and omitting to benefit by the experiences of the previous workers, essays to take even a humble share in the "Evolution of Machines."

DISCUSSION.

Professor PERRY said one was naturally struck on going on board a large ship like the *Devastation* with the idea that machines were getting exceedingly complicated, and as it was now about 15 or 16 years since he had made such a visit, he had no doubt that still more complicated machines were in use now. Still, on carefully examining the machinery, he found he could understand it. For instance, there were a number of fans for ventilating the ship, and collectively they made a complicated looking piece of apparatus, though the parts were simple enough. If he differed in opinion from Professor Shaw, it was on account of the different meaning which he attached to the word "complicated." To consider the culminating example of the engines of the Atlantic liner giving, say, 10,000 horse-power to the propeller shaft. Now, consider how Watt, 100 years ago, would have given this horse-power to a shaft. If he had been asked to do this, he could have done it, and he would probably have put in 100 of his engines, filling the ship with machinery. It was also quite within his powers to have arrangements which would enable all his 100 engines to stop or reverse at the same time, and instead of the 100,000 parts of existing engines, he would probably have used in all his engines and boilers ten times the total number of rivets and nuts and other pieces. In fact, to give 10,000 horse-power to a shaft in Watt's days would have needed machinery much more complicated than the machinery in use at the present day. Professor Perry contended that it was on account of the complicated nature of the known machinery necessary, that large steamships were not driven across the Atlantic sixty years ago, and that it was the simplification of construction of steam-engines which had enabled huge Atlantic liners to be workable. Although, no doubt, there was a law of evolution in machinery, it would be rather rash to conclude that they knew what that law was. It was all very well to tell inventors of gas-engines that there was no hope of getting much greater efficiency than had yet been attained, but they knew that a great deal had been done in the past, and he believed that if people went on hammering their heads long enough against this wall of the materials not being useable at very high temperatures, they would discover new materials, or some way of getting round the difficulty. It was said that by Taylor's theorem, if you knew the complete motion of a particle, its exact position in space, its velocity, acceleration, and a variety of other things, all included in an exact knowledge of its present state, you could prophecy the position of that particle millions of years hence, and tell what its condition was millions of years ago; and it seemed to follow certainly, from the theorem, that you could do so. In the same way, if they knew the law of the evolution of machines, as some higher beings might know it, they might be able to say what machines would come to a few million years hence. But they did not know the law of the evolution of machines; they knew very little of it. The country of Erehwon would probably be known to most of the audience who could spell backwards, and there the people thought they knew the law of the evolution of machines exceedingly well; they saw machines

getting more and more powerful, and men getting more and more the slaves of machines, which were becoming more and more automatic, and more and more capable of self-production, so that after a time they feared there would be no room left for human beings on earth, except as parasites, and so they broke up the machines, and when the great traveller who discovered the country visited them, he found they were using very common implements, the fields produced very little wheat, and they were not surrounded with very many comforts. All this evil proceeded from their having the notion that they knew a great deal about the evolution of machines.

Professor HUGHES, F.R.S., thought all must agree in the main points of the theory which Professor Shaw had put forward, because he had shown the evolution of these machines, but he had not shown the failures, and he could not say that these stepping stones showed exactly the law. It was certainly a great thing to know what had been done, but great things had been done by men who really knew nothing of what had been done, and which never would have been done had they known it. Take for instance the telephone, all scientific men would have pronounced it to be perfectly impossible; and if Professor Bell had passed his life in studying the science of telegraphy, he never would have invented it. There was, therefore, a good deal to be said on both sides of the question.

Mr. HIRAM MAXIM then described at some length the construction, and showed the mode of working his patent gun. He said the complication to which the reader of the paper had alluded was not a necessary part of the gun; it might have been made to load and fire itself without so much complication; but these complications were introduced in order to allow of the magazine for the cartridges being placed under the gun instead of over it, where it was more exposed, and of its continuing to fire automatically with no attention beyond that of one man who directed the fire. Some other guns required two men to put the cartridges in at the top, and one to turn the crank for firing, and another to turn the gun about, which made the motion very slow, the cartridges falling into their place by the action of gravity. In this gun they were arranged in a belt from which they were taken one by one, and a belt might be made to hold 2,000, if necessary. The speed was adjustable by the trigger, and could be made as high as 600 per minute. The gun could be adjusted so as to have a horizontal fixed range between two points, and thus, if works destroyed in the day were repaired by the enemy in the night, the bearings and levels could be taken in the day time, and fixed, and at night the gun could be kept firing between these two points all night, by simply a boy to move it slowly from side to side; and he should not be surprised to find that the boy, like the one they had heard of, had devised some plan for making the gun do this automatically. There was such beautiful adjustment in every direction, that you could easily write your name on a screen with it. Having described the means by which the recoil from each shot was utilised to extract the empty cartridge case, Mr. Maxim concluded by saying that when once put into work, the gun would go on firing, if desired, until the man who paid for the cartridges was in a hopeless state of bankruptcy.

The CHAIRMAN said he gathered from the paper that Mr. Hele Shaw's notion was that the evolution of machinery tended to complexity, and that did not seem very unnatural. As time went on, persons found that devices which they thought would not work, and would get out of order, would work, and could be trusted; they then thought if they could trust one, they could trust two, and so they used two instead of one, with the result that certain functions which had formerly been performed by humanity might be performed by apparatus. Therefore, owing to improvements not only in material, but also in workmanship, machinery became more trustworthy, and, as a consequence, more complicated, and greater benefits were derived from it. He had been much interested in the two early lathes which had been shown, one where the operator held the tool down with his toe, as he had often seen done in Cairo, and the other, the old pole-lathe, the implement on which he first learned to turn. He was sorry to hear Mr. Shaw treat the attempt to make a rotary steam-engine as a retrogade movement. In his judgment it was a reproach to mechanics that they had to begin with a reciprocating movement when they wanted to end with a rotative one; and he could not help thinking that those who, time after time, attempted to solve this problem were deserving of their thanks. He agreed very much with Professor Perry, that there was a good deal to be said on both sides of the question whether inventors ought to know everything which had gone before; and with Professor Hughes, that no one who had been familiar with the science of electricity would ever have dared to think about the telephone. Again, to call to mind the wonderful boot-sewing machine of Blake, which it was agreed on all hands the inventor never would have invented had he known anything about boot-making. No doubt there was considerable danger, when a man studied all that had gone before, that his mind would get into a groove, and thus he would not make really substantive inventions. When speaking on the Patent-laws, he had often pointed out that a very favourite suggestion of the opponents of such laws, that there was no need for them because the inventor would be rewarded by making the thing he invented and selling it, was a fallacy, inasmuch as very often the man who had made substantive inventions had been wholly unconnected with the trade to which they referred, and was, therefore, incapable of competing commercially with those in the trade. This being so, he was inclined to doubt the soundness of the suggestion that all persons, before beginning an inven-

tion, should know everything that had gone before. In the conclusion of the paper, comment was made on the large number of patents applied for, in comparison with those which were completed. He, for one, was very glad to see that difference, because it represented the value which they had contended so much for in all these patent questions—the time of the provisional protection giving the patentee time to experiment and make inquiry. By that means he found out that he was wrong, that the thing would not do, that it was not novel, or that for some other reason the thing could not be gone on with, and in that way the full benefit was secured, both to the inventor and the public. He looked on the number of abandoned patents as by no means a thing to be deplored, but as an evidence of the care and forethought exercised by inventors before going on to complete their patents. He concluded by proposing a vote of thanks to Professor Shaw.

The vote of thanks having been carried unanimously,

Professor HELE SHAW said the first three speakers had almost entirely corroborated, at any rate, the tenor of his remarks. He had not been able to develop his ideas completely, for when he came to write the paper, he found that the subject really required a book, and he had to leave off where he should have liked to begin. He believed the general theory of evolution did hold good with regard to machines, and when Professor Perry said he did at last understand the machinery of a large ship, what more striking proof of the truth of his views could be desired. Again, the same thing occurred when Mr. Maxim explained why he had been led to complicate his gun, namely, to make it a more efficient machine. When he used the term complexity, it did not necessarily mean the addition of parts which would get out of order, but that with the progress and development of the manufacturer's arts, increased complexity would be a synonym for the increased certainty of action, as had been the case with many machines. With reference to Professor Hughes' remarks, he might say that he had already quoted Herbert Spencer's words, showing that progress was the differential result of a periodicity of action and reaction, of backward and forward motion. With regard to the rotary engine, he believed there was now a successful one at work, the Tower spherical engine, which was a marvellous piece of mechanism. He was referring not to the effort to make a rotary engine, but to the way in which those efforts had been made, through ignorance of the principles applicable, one after another having gone on in the same hopeless way, until Mr. Tower had struck out a new line. This had resulted in a motor which though externally it looked very simple was really anything but this, and required elaborate arrangements, and no less than thirty-two figures to completely explain its action and various parts. There was such a thing as degeneration in machines; such a thing as machines made for a higher purpose having for certain reasons to submit to the process of degeneration. The locomotive, vast though its influence on civilisation had been, as a type of an efficient motor, and regard simply being had to its maximum efficiency, had certainly degenerated from the condensing engine of Watt. He had not been driving a pet theory, but simply calling attention to what he believed a general law of progress in machines. He had not been quite understood with reference to the line on the curve of application for patents, which showed not only how many never reached completion, but also the immense increase in inventions, and this he had endeavoured to show was clearly tending to the absolute necessity for a more scientific classification than at present adopted. A great many men spent hundreds or thousands of pounds for want of knowledge; it was the knowledge of that kind he was advocating; not the knowledge which would prevent them going further, which was simply that little knowledge which was a dangerous thing.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

PHOTOGRAPHY.

The Executive Council invite tenders for the exclusive right of taking photographs in the International Inventions Exhibition, 1885, during the continuance of the Exhibition.

The contractor will be allowed to take photographs of any part of the Exhibition or gardens the property of the Executive Council, and to take photographs of exhibits, under arrangement with the exhibitors; he will also be allowed to take portraits.

The contractor will be granted two stands for the sale of photographs, the position and size of such stands to be decided by the Council; he will also be provided with space in the gallery above the East Arcade for a developing-room, and for such other purposes as may be necessary; and he will be permitted to erect and fit up a studio for portraiture in the same position if he desires it. The Council will provide gas and water, but all fittings must be provided by the contractor.

Plans showing the position of the spaces to be alloted for the above-mentioned purposes can be seen at the Secretary's office.

Electric light for the purposes of photography will be provided by the Council at cost price.

The exclusive privilege granted to the contractor is not to prevent exhibitors in Group XXIX. (Photography) from carrying on, for purposes of exhibition

and illustration only, any photographic processes whatever.

The exclusive privilege is not to prevent exhibitors from distributing gratuitously any photographs of their exhibits, or any part thereof; but such photographs will not be allowed to be taken in any part of the buildings except by the contractor.

The person tendering will be required to specify in his tender *(a)* the per-centage on gross receipts which he will undertake to pay for his privilege, together with *(b)* the amount of the said per-centage he will pay by way of premium on the signing of the contract.

A schedule of prices, at which the contractor will undertake to supply the exhibitors with photographs of their exhibits, must be appended to the tender.

Forms of tender can be obtained from the Secretary, and tenders must be sent in not later than the 14th March.

NOTES ON SILK-PRODUCING BOMBYCES REARED IN 1884.

By Alfred Wailly.

(Continued from p. 307.)

Attacus cynthia.—In 1884, I only had a very small number of *Cynthia* cocoons, about twenty; these were sent me from the United States of North America, where the species is now naturalised. The moths emerged from the 28th of June to the 6th of July. With twenty moths eleven pairings were obtained, several of the males having paired twice; the larvæ were reared this year entirely on lilac trees and with the greatest success, the formation of the cocoons commencing on the 21st of September. In 1883, the larvæ were reared principally on laburnum trees, and very few cocoons were obtained from the lilac trees.

Antheræa Pernyi.—Of this well-known acclimatised species (imported like *Attacus cynthia*, about thirty years ago, from North China), I received over fifty cocoons from the South of France, and also some eggs and cocoons from Spain. The cocoons from France arrived on the 20th of March, but in consequence of the abnormally warm weather, several of the moths had emerged during the journey. The moths continued to emerge until the 23rd of May, a long time for the emergence of all the moths of this hardy species, but this was due to the great changes of temperature which happened during the interval of these two months. A great number of pairings took place. The ova kept by me for rearing commenced to hatch about the 15th of May, and the cocoons were formed during the first fortnight of July. The larvæ were reared in a room, on large cut oak branches, and the cocoons I obtained were very fine.

Hybrid Roylei-Pernyi.—From my article on this hybrid in my report on the rearings of 1883, it will be seen that I stated that it had disappeared, and become extinct in that year, owing to numerous causes enumerated in my report; but I then stated that I did not think the degeneracy of the species with me was due to the fact that my new silkworm was a hybrid, and I was right. The hybrid which I then believed extinct is still in existence. With the fifty *Pernyi* cocoons I received from the south of France, from the Département des Landes, my correspondent also sent me fifty cocoons of my hybrid *Roylei-Pernyi*, which had been, every year since I introduced it, successfully reared up to the present time in that southern department. I obtained in 1884, about 150 cocoons by rearing larvæ of one brood only, and I expect some more cocoons from the same correspondent for the rearings of 1885.

A most distinctive characteristic of the hybrid *Roylei-Pernyi* was the tough thick envelope which closely covered the inside or true cocoon. Now, a most extraordinary transformation has taken place with respect to this cocoon; it has completely thrown off the overcoat it used to wear in the first two years of its existence, and it now appears with the plain coat of the *Pernyi*, while the moths, up to the present time, have remained the same as they originally were. The cocoons alone have undergone a change, the moths have not, at least, not to any perceptible degree, but they may do so in course of time. Some entomologists state that this reversion of hybrid species to one of the parent types is not an unusual fact. Is this gradual disappearance of certain characteristics in hybrid species due to the fact that originally the parent species were the same instead of being distinct species? I am inclined to believe that such is the case. Greater differences exist in the various races of the Indian *tussah* (*Mylitta*), than there are between *Pernyi* and *Roylei*, and greater differences still in the various races of *Attacus atlas*, a species which is found in China, India, Ceylon, and probably in all the islands of the Indian Archipelago. What are the differences between *Pernyi*, the North China oak silkworm, and *Roylei*, the Himalayan oak silkworm? The larvæ, it may be said, are identical; the moths only differ in *Roylei*, being of a lighter colour; the cocoon alone shows a greater difference, that of *Roylei* being surrounded by a large, irregularly shaped envelope, which does not exist on the *Pernyi* cocoon. But, if we consider the numberless varieties of the mulberry silkworm (*Bombyx mori*), obtained by centuries of rearings of the same original species in different countries and climates, may it not be possible that *Roylei* and *Pernyi* are only the same species with characteristics due entirely to differences of climate, food, and to other influences?

The moths of the hybrid *Roylei-Pernyi* emerged at the same time as the *Pernyi* moths, and pairings took place between the two, as well as among the hybrid ones among themselves. The first pairing of the hybrid moths took place on the 26th of April, and only the larvæ of this pairing were reared by me. They hatched on the 22nd of May, and the first cocoons were obtained on the 24th of July.

The cocoons after their formation were placed in a

cool cellar, so that none of the moths emerged during the autumn, thus securing the cocoons for the rearings of 1885. I have not observed any difference between the larvæ and the cocoons of the hybrid by comparing them with those of the *Pernyi*; therefore, the only object of interest is to see how long the moths will keep distinct from the *Pernyi* moths in their lighter shades of colour. The larvæ thrived remarkably well, without any fatality, first on little oak trees in the garden, and later on, in the fourth and fifth stages, when nearly all the foliage had been eaten, the larvæ were reared on large cut branches in the house.

Attacus atlas.—No success whatever was obtained with this species; at least, there was no possibility of obtaining fertile ova for the rearing of the larvæ. From a few cocoons of the large Himalaya race, which I had left from the year 1883, two female moths emerged; the first, on the 6th of July, was an imperfect specimen; the second, a perfect and splendid specimen, emerged on the 21st of July. From a number of cocoons of the Ceylon race, three moths only were obtained; a female on the 4th of September, a male on the 9th, and another male on the 20th of the same month. A small case of *Atlas* cocoons, which I received on the 25th of September, contained, to my great surprise, the largest proportionate number of live cocoons I ever received from that tropical country; the cocoons which had not hatched, and they were in a majority, are the largest I ever received from Ceylon; the larvæ were reared on growing cinnamon trees. On the contrary, a case containing 111 cocoons, received on the 13th of November from the same country, only contained a few live cocoons, all the others having hatched during the voyage. The box was full of broken wings and dust.

On the 18th November, 1884, I received from my correspondent in Ceylon two most interesting letters on the rearing of *Attacus atlas*, and *Antheræa mylitta*, from which I shall reproduce the most important communications, some being from my correspondent's wife, who this year has conducted the rearing with the greatest ability and success. Writing on the 12th of October, my correspondent says:—"The *Atlas* cocoons I sent you are better than those previously sent, as the larvæ were reared on growing cinnamon bushes under a net in the open air, whereas the previous ones had been kept all their life on cut *milnea* branches inserted in water. The latter plan does well enough for the production of cocoons for manufacturing purposes, but the moths are not so large and strong as when the larvæ have been kept on growing trees. There would be no question about its being better for any purpose to feed the larvæ on growing trees, were it not that in this country it is indispensable to cover the trees with netting, and it is doubtful if it would be remunerative to cover in a whole plantation that way. You will observe that the cinnamon seems to produce a silk of superior quality to other trees. I have always thought the silk of the *Atlas* better than that of the *Mylitta*, if the former could only be utilised; but I had almost despaired of ever being able to make anything of it, because *Atlas* cocoons cannot be reeled, and they are so tough in their natural state, that they would break the teeth of a carding machine. Only a week ago, however, I did succeed in drawing out the silk from the *Atlas* cocoon, and it was more by accident than by good management that I found out how to do it. Some time ago I boiled, with carbonate of soda, some empty *Atlas* cocoons along with *Mylitta* ones containing pupæ that had been long dead, and were quite dried up. The *Mylitta* cocoons were softened by the boiling, but the *Atlas* ones remained unmanageable; so I put the latter in a stoppered bottle to steep in the water they had been boiled in. I examined them after some days, and the steeping had not had any effect on them. Then I forgot about them for two or three months, and I found them last week after I thought they had been thrown away long ago. They smelt very nasty, but they were quite soft, so that the fibre could be easily drawn out. I do not know whether the effect was due to the carbonate of soda or the decoction of *Mylitta* pupæ, or if prolonged steeping in pure water would have had the same result; but whatever the cause may have been, the effect was very satisfactory. I send you a sample, and if you pull out the silk from the open end of a *Tussur* cocoon, and compare the two samples, you will see that the *Atlas* is more soft and lustrous than the *Tussur*. The *Atlas* is dark in colour, but the colour is not in the silk itself, as it is quite white when it comes from the mouth of the silkworm, and is stained by the fluid which the insect discharges upon it afterwards, so that it could be made white by bleaching. Only four cocoons are required to produce the quantity of silk in the sample sent. The *Atlas* moth is more easily bred than the *Tussur*, as the larvæ do not move about so much, and the moths are very quiet, allowing themselves to be handled and carried about without attempting to fly away."

CIVILISATION AND EYESIGHT.

The following communication from Lord Rayleigh appeared in the number of *Nature* for February 12:—

In his interesting paper on "The Influence of Civilisation upon Eyesight," read recently before the Society of Arts, Mr. Brudenell Carter supports the commonly received view that the vision of savages is far more acute than that of civilised men. In some sense this is doubtless true; but that the eyes of savages, considered merely as optical instruments, are greatly superior to our own appears to be inconsistent with optical laws and facts long since established by the labours of Airy, Helmholtz, and other investigators. It is known to physicists that the resolving power of an optical instrument is limited by its aperture.

With a given aperture no perfection of execution will carry the power to resolve double stars, or stripes alternately dark and bright, beyond a certain point, calculable by the laws of optics from the wave-length of light. With sufficient approximation we may say that a double star cannot be fairly resolved unless its components subtend an angle exceeding that subtended by the wave-length of light at a distance equal to the aperture. If we take the aperture of the eye as 1-5th inch, and the wave-length of light as 1-40,000th inch, this angle is found to be about two minutes; and we are forced to the conclusion that there is no room for the eye of the savage to be much superior in resolving power to those of civilised physicists, whose powers approach at no great distance the theoretical limit as determined by the aperture.

It has always appeared to me that the superiority of the savage is a question of attention and practice in the interpretation of minute indications, and that it is comparable with the acuteness of the blind in drawing conclusions from slender acoustical premises. It would be an interesting subject for investigation, but I should not expect to find that, when put to a direct test, blind people were able to hear sounds wholly inaudible to others.

The increasing prevalence of short sight is a very important matter, worthy of all attention. There is one fact in connection with it which I avail myself of this opportunity of mentioning, in the hope of inducing scientific oculists to give it further examination. I find that, though not at all short-sighted under ordinary circumstances, I become decidedly so in a nearly dark room, seeing much better with spectacles of 36 inches negative focus. In a moderately good light I see rather better without the glasses than with them. From the few observations that I have made, I have reason to believe that this peculiarity of vision is not uncommon. With the aid of a set of concave glasses it is easy to try the experiment in a room lighted with gas. The flame should be gradually turned lower and lower, so as to give full time for the pupil to dilate, and for the eye to acquire its maximum sensitiveness. In my own case the most marked indication of better definition is the augmentation of binocular relief.

Mr. Brudenell Carter's reply, which is as follows, appeared in *Nature* for February 26:—

Lord Rayleigh questions whether the eyes of savages "merely as optical instruments," are greatly superior to our own; and suggests that any superiority which savages possess may depend upon "attention and practice in the interpretation of minute indications." He explains that "the resolving power of an optical instrument is limited by its aperture," and then proceeds as follows:—

"With a given aperture no perfection of execution" [as above to] "as determined by the aperture."

I understand this to mean that optical conditions limit the resolving power of the eye to objects which subtend a visual angle of about two minutes, and that civilised physicists approach this theoretical limit at no great distance.

With great submission to the high authority of Lord Rayleigh, I venture to question whether we have any data from which to draw conclusions with regard to the possible optical powers of the eyes of the human race. We should probably fall into grave error if we were to argue from the reduced eye of Listing, or even from the eyes of the small number of persons whose visual function has been minutely tested, to the properties, as optical instruments, of the eyes of mankind in general. "La position," writes Helmholtz, "des foyers, des points principaux et des points nodaux de l'œil est assurément soumise à des variations individuelles assez importantes, puisque la plupart des mensurations de l'œil et de ses diverses surfaces réfringentes présentent, chez différents sujets, des différences plus grands qu'on ne paraissait devoir les attendre pour un organe dont les fonctions semblent réclamer une si grande exactitude de construction."

As a matter of fact, the theoretical limit of resolving power assigned by Lord Rayleigh, to which he tells us that civilised physicists "approach," is one which civilised physicists have considerably exceeded. The mean of twelve observers, as quoted by Helmholtz, gives resolving power under a visual angle of 101 seconds; and this mean is reduced by two cases in which the angles were 124 and 147 seconds respectively. The minimum was 51 seconds, the most frequent angle was about 80 or 90 seconds. The commonly accepted standard of normal vision among civilised people is satisfied by deciphering letters, the parts of which subtend visual angles of one minute, while each letter as a whole subtends a visual angle of five minutes.

I cannot say, however, that I think any such tests are very material to the issue. The eyes of civilised physicists, or of such of them as have undertaken practical research in physiological optics, are probably very highly cultivated; and I doubt whether resolving power, which must greatly depend upon the functional activity of the central depression of the retina, or, in the case of stars, upon the functional activity of the zone which immediately surrounds the yellow spot, furnishes any accurate test of acuteness of vision in the sense in which I employed the phrase.

Assuming the civilised man and the savage to have eyes of precisely equal optical value, the latter might yet possess an acuteness of vision greatly in excess of that of the former; and this excess might be due to conditions of the percipient elements of the retina, which, in the case of the savage, permitted the optical powers to be utilised to the fullest extent. The savage might have greater sensitiveness to variations of light, greater sensitiveness to colour, and acuteness of vision over a larger retinal area. All these advantages might be conferred by better formation or higher development of the retina, and such higher

development might at once be promoted by exercise, and handed down by descent. I support the "commonly received view" that the vision of savages is more acute than that of civilised men, because this view seems to me to be established by abundant testimony, and to be in perfect harmony with physiological knowledge. I feel very strongly that the conditions of town life are unfavourable to the evolution of the eye and favourable to its involution or degradation; and I believe that a moderate amount of attention might greatly modify these conditions, and might do for the eyes what is done by athletic games and exercises for the muscles.

With regard to the improvement of Lord Rayleigh's own vision, in a dim light only, by concave glasses, I think his Lordship cannot fail to see that the case, as stated, does not contain all the data which would be required in order to arrive at an explanation of the phenomenon.

Several other letters on the same subject have appeared in *Nature.*

SHEEP REARING IN RUSSIA.

Consul Stanton, of St. Petersburg, says that in many districts in Russia, especially in the Southern and Asiatic Steppes, sheep are the most important of domestic animals. The common breed is found throughout the Empire, but in the south, the district in which the finer races abound, they are kept only by the peasants, who, except in Tamida, do not rear the fine wool species. The common sheep embrace many subordinate classes, the leading ones being the Kirghese and the Wallachian. Of late years, very little has been done to improve the common breed of sheep, but recently English and Turkestan sheep have been imported for the purpose of crossing with these animals. The development of the merino sheep is due entirely to governmental measures. At the commencement of the present century sheep were imported from Spain, Switzerland, France, Saxony, and Silesia, the Government providing large sums for this purpose, and encouraging the introduction of fine merino sheep in every possible manner. At first Russian breeders kept up the breed of fresh importations, but ceasing to do this, the merino sheep, under climatic influences, became an animal with coarse and thick wool. According to official returns, there were in 1880, in European Russia and Poland, 48,198,000 sheep, 37,391,000 being common, and 10,807,000 merinos. Compared with 1876, little or no alteration has taken place in the whole number. Common sheep increased slightly, and merinos decreased about 15 per cent. The domestic trade in New Russia is chiefly in the hands of Jews, in the Don district in those of Armenians, in Great Russia in those of Russians, whilst Tartars monopolise the trade in the districts of Saratov, Pensa, Simbirsk, and Volga. These dealers travel from village to village, buying up single lots, which are resold to large dealers. Tallow boilers consume about 2,500,000 sheep annually. The coarser wool is used for manufacturing military cloth, and is generally sold unwashed. The foreign export trade is chiefly carried on at the ports of Odessa, Riga, and St. Petersburg, the wool being thoroughly washed. The leading wool markets are at Charkoff, Ekaterinoslaff, Poltava, Tamboff and Pensa. About 36,000 tons of merino wool, valued at from £1,600,000 to £2,000,000, are annually produced in Russia. The Vistula and Don wools are most in demand, the former for its fineness, the latter for its cheapness.

TRADE OF LYONS.

According to a statement in the *Central Blatt für Textil Industrie,* the production of silk goods in Lyons, for the last four years, was as follows:—1880, £14,400,000; 1881, £9,600,000; 1882, £5,840,000; 1883, £5,640,000. A further reduction will, it is considered, be shown in the returns for 1884.

Various causes have contributed to the above result. Lyons manufacturers, who at one time commanded the world's markets, have now important competitors in Germany and Switzerland. This competition does not extend to the better classes of goods (from 13s. per yard upwards); but this fact does little to alleviate the condition of business, inasmuch as nine-tenths of the European consumption of silk goods may be classified amongst various articles containing an admixture of cotton ranging from 40 to 90 per cent., and starting from a very low range of prices. Up to the year 1880, an attempt was made to hold a position against German and Swiss rivals, and the production of goods containing admixture of cotton had rapidly increased from £1,400,000, in 1877, to nearly five times that amount in 1880, when this class of goods represented about one-half of the entire outturn. Since that period there has been a gradual falling off, and the amount for 1833 was only £3,800,000. An examination of the course of pure silk goods reveals a still further retrogression, as the production in this branch has dropped from nearly £8,000,000 in 1880, to £1,800,000 in 1883.

The temporary free admission of the finer counts of cotton yarn into France has not been productive of the benefits at one time anticipated. It is stated that about nine-tenths of the yarn imported is under the limit of fineness specified by the decree in question. Hence, Lyons has not gained much by the new arrangement, and efforts are being made to obtain a more extended application of this principle. French spinners are making counter-representations to the authorities, as the step asked for would, it is believed, be fatal to them. The difficulties of the position are intensified by the fact that the French duty on cotton yarn is six times greater than that levied in Germany.

Notes on Books.

Annals of Lloyd's Register, being a Sketch of the Origin, Constitution, and Progress of Lloyd's Register of British and Foreign Shipping. London: 1884.

The Chairman and Committee of Lloyd's Register have taken the opportunity of the fiftieth anniversary of the foundation of the society to issue to the subscribers an account of the origin and progress of the institution. It appears that the earliest notice at present found of the "Ships' List," which were kept for the guidance of the frequenters at Lloyd's Coffee-house, is in the shape of an advertisement in the *London Gazette*, of 18th February, 1668. The Coffee-house was owned by Edward Lloyd, under whose management it became the resort of all persons connected with shipping. Lloyd's List was commenced in 1726, and has continued to the present day. The first Register of Shipping is supposed to have been published about 1726. The underwriters and brokers who so long made the Coffee-house their meeting place, formed themselves into an Association in 1770, and their first place of meeting was in Pope's Head-alley. A few years later they went to the Royal Exchange. The oldest copy of a Register of Shipping in the library of Lloyd's Register-house, bears the dates of 1764-65-66. The work under notice contains a full account of the Register, and of the various changes in classification from this time to the present, and also contains an account of the constitution and *personnel* of the Association.

Bartolozzi Prints. London: Field and Tuer.

Messrs. Field and Tuer, the publishers of Mr. Tuer's book on "Bartolozzi and his Works," have ssued a selection of stippled prints, taken from the original copper-plates of Bartolozzi, the subjects including "Pheasant Shooting," "The Reverie," "Spring," and "Winter," &c.

General Notes.

Condensing Machinery.—A large condenser, for the purpose of converting sea water at Suakim into drinking water for the troops, has been fitted up in the cable steamer *Calabria*, chartered by the Admiralty from the Telegraph Construction and Maintenance Company. The machine (which is the invention of Mr. John Kirkaldy) consists of ten distillers, with filters attached, each capable of producing 6,000 gallons of water every twenty-four hours.

Amateur Photography.—An Exhibition of Photographs by Amateurs will be held at 103, New Bond-street, from April 23rd to May 9th, 1885, inclusive. It will be divided into thirteen distinct classes, and for the best pictures the London Stereoscopic and Photographic Company will give a gold, silver, or bronze medal. In addition, extra prizes will be given by the Coventry Machinists' Company, Messrs. Edwards, and by the Proprietors of the Platinotype process, the total value of prizes being over £200. The judges will be Mr. Thomas Faed, R.A.; Captain Abney, F.R.S.; and Mr. J. Duncuft. Intending exhibitors should apply at once to the offices of the London Stereoscopic and Photographic Company, 108 and 110, Regent-street.

Liljeholmen Foundry.—The Swedish Government has issued a circular respecting the work of the foundry established at Liljeholmen, near Stockholm, under the authority of the State, where certificates are given respecting the strength of the materials submitted for examination. It is stated that the establishment has gained the entire confidence of the marine, artillery, and railway adminstrations. The Swedish Admiralty have, for some years, required all their guns to be submitted to this establishment before they are delivered to them. The Swedish Government are anxious that the value of the certificates given at the Liljeholmen foundry should be known to foreigners, so that they may take advantage of the privileges offered them.

Spanish Zinc.—The only zinc works in Spain belong to the Société Royale Asturienne. They are located at Arnao, near Aviles, in Asturias, in a small coal basin, separated from the central coal basin. These works treat ores coming from the provinces of Santander and Guipuzcoa, with twenty-two Belgian furnaces, blende roasting furnaces, and a sheet zinc rolling plant. In 1881, 320 men were employed. In 1881, the production was 4,910 metric tons of zinc from 13,000 tons of ore, while in the preceding year it was only 4,221 tons. The production of sheet zinc was 2,125 tons. In 1881, the export of spelter amounted to 1,743 metric tons, of which 1,515 tons went to France and 228 tons to Cuba. It appears, therefore, that the consumption of Spain is 1,042 tons of spelter and 2,125 tons of sheet zinc—a total of 3,167 tons. In 1881, the export of zinc ore was 39,774 tons, of which 31,927 tons were calamine and 8,547 tons were blende. Adding to these figures the 13,000 tons treated at Arnao, a total of 53,834 tons is reached, or more than 10,000 tons more than the production returned by official statistics.

Wild Plant Fabrics. — A most interesting example of utilisation of waste products is to be seen in a shop window in New York, in the shape of a number of hanks of thread of different textures and colours, some being as soft as the finest silk, others

as rough as hemp. These hanks are the result of an attempt, which seems likely to be successful, to utilise the various wild grasses and stalks for textile purposes. The cotton stalk, which in the South has been hitherto burnt as useless trash, is here made into a coarse thread fully equal to Indian jute, an article of commerce which is imported into the United States to the amount of 6,000,000$ per annum. Flax straw, which is also a very common waste product in many of the States, is converted into a fibre which makes excellent linens, and serves also as a substitute for cotton when mixed with wool. These, however, are only a few instances of many materials which have been experimented upon with more or less valuable results. Among them are the bear grass, Spanish bayonet, okra, nettle, ramie, pita, wild coffee, and the cotton plant, all of which grow wild; and from them are produced various fibres which dye beautifully, and can be made into bagging, rope, packing thread, and paper of the finest quality, fabrics for dress, and materials for upholstering purposes. It has been found, too, that ramie and Sisal hemp fibre can be mixed with silk to great advantage, while the common American grasses are turned into fibre strong and good enough for false hair and wigs. The cocoanut shell yields a fibre quite equal to curled hair for upholstering uses. Another conversion into fibre which seems likely to be of practical value is that of the mineral asbestos, which is as fine as silk, and can be made up into fireproof curtains and hangings for walls and theatres, fireproof ropes, carpets, and, in fact, every kind of house decoration.—*Times*.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at Eight o'clock:—

March 11.—"Exploration, and the Best Outfit for such Work." By Major-General the Hon. W. Feilding. Francis Galton, F.R.S., will preside.

March 18.—"The Rivers Pollution Bill." By J. W. Willis-Bund. Capt. Douglas Galton, C.B., F.R.S., Vice-President of the Society, will preside.

March 25.—"Introduction of the Beet Sugar Industry into England." By Colonel Sir Francis Bolton.

Papers for reading after Easter:—

"The History and Manufacture of Playing Cards." By George Clulow.

"The Musical Scales of Various Nations." By A. J. Ellis, B.A., F.R.S.

"A Marine Laboratory as a Means of Improving Sea Fisheries." Professor E. Ray Lankester, M.A., F.R.S.

"Recent Improvements in Coast Signals." By Sir J. N. Douglass.

"The American Oil and Gas-fields." By Professor James Dewar, F.R.S.

Indian Section.

Friday evenings at Eight o'clock.

March 6.—"The Trade between India and the East Coast of Africa." By Frederic Holmwood, British Consul at Zanzibar. Major-General Sir Frederick J. Goldsmid, K.C.S.I., C.B., will preside.

March 13.—"The Present Condition and Future Prospects of Female Education in India." By Mancherjee M. Bhownaggree, late Secretary of the Alexandra Girls' English Institution, Bombay. Matthew Arnold, D.C.L., will preside.

April 17.—"The Parsis and the Trade of Western India." By Jehangeer Dosabhoy Framjee.

May 8.—"The Ancient and Modern Methods of Treating Epidemics of Small-pox in India." By Robert Pringle, late Sanitary Department H.M. Bengal Army. Sir Philip Cunliffe-Owen, K.C.M.G., C,B., C.I.E., will preside.

May 15.—"The Golden Road to South-Western China." By R. K. Douglas, Professor of Chinese at King's College, London.

Foreign and Colonial Section.

Tuesday evenings at Eight o'clock.

March 17.—"The Congo and the Conference, in reference to Commercial Geography." By Commander Cameron, R.N., C.B.

March 31.—"Kiliman'jaro and the Surrounding District of Equatorial Africa." By H. H. Johnston.

April 28.—"The Federation of the Empire." By J. E. Gorst, M.P. The Right Hon. W. E. Forster, M.P., will preside.

Applied Chemistry and Physics Section.

Thursday evenings at Eight o'clock.

March 12.—"Recent Improvements in Photographic Development." By W. K. Burton. Capt. Abney, F.R.S., will preside.

April 23.—"The Chemistry of Ensilage." By Frederick J. Lloydd.

The dates given above are subject to alteration.

Cantor Lectures.

Monday Evenings at Eight o'clock.

The Fifth Course, "Carving and Furniture." By J. Hungerford Pollen.

Lecture I. March 9.—Types and Fashions of the Wood Carvers' Art.

Lecture II. March 16.—The Renaissance.

Lectures III. & IV. March 23 & 30.—The Age of Gibbons, Boule, and that of their successors.

The Sixth Course, "Photography and the

Spectroscope." By Captain C. W. DE W. ABNEY, R.E., F.R.S.
April 20 and 27.

The Seventh and concluding Course, "The Manufacture of Toilet Soaps." By C. R. ALDER WRIGHT, D.Sc., F.R.S., F.C.S.
May 4, 11, and 18.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 9...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. J. Hungerford Pollen, "Carving and Furniture." (Lecture I.)

Surveyors, 12, Great George-street, S.W., 8 p.m. Adjourned discussion on Mr. R. W. Mann's paper, "The Enfranchisement of Urban Leases," and on Mr. H. Martin's paper, "Recent Proposals for Leasehold Enfranchisement."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. R. Gordon, "The Irawadi River."

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. H. H. Statham, "Architectural Character and Expression."

TUESDAY, MARCH 10 ..Royal Institution, Albemarle street, W., 3 p.m. Prof. Arthur Gamgee, "Digestion." (Lecture II.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr. Wm. Stroudley's paper, "The Construction of Locomotive Engines, and some Results of their Working on the London, Brighton, and South Coast Railway."

College of Physicians, Pall-mall East, S.W., 5 p.m. (Croonian Lectures.) Dr. Hermann Weber, "Hygienic and Climatic Treatment of Consumption." (Lecture I.)

Photographic, 5a, Pall-mall East, S.W. 8 p.m.

Anthropological, 3, Hanover-square, W., 8 p.m. 1. Mr. James G. Frazer, "Certain Burial Customs as Illustrative of the Primitive Theory of the Soul." 2. Rear-Admiral F. S. Tremlett, "The Sculptured Dolmens of the Morbihan."

Colonial Inst., Grosvenor Gallery Library, 136, New Bond-street, W., 8 p.m.

WEDNESDAY, MARCH 11...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Major-General the Hon. W. Feilding, "Exploration, and the Best Outfit for such Work."

Geological, Burlington-house, W., 8 p.m. 1. Dr. C. Callaway, "The Granitic and Schistose Rocks of Donegal and some other parts of Ireland." 2. Mr. Grenville A. J. Cole, "Hollow Spherulites and their occurrence in ancient British Lavas."

Graphic, University College, W.C., 8 p.m.

Microscopical, King's College, W.C., 8 p.m. 1. Mr. J. W. Stephenson, "A New Catadioptric Illuminator." 2. Dr. J. D. Cox, "Structure of the Diatom Shell, Siliceous Films too Thin to show a Broken Edge." 3. Messrs. F. R. Cheshire and W. W. Cheyne, "The Pathenogenic History of a New Bacillus (*B. Alvei*, Cheshire)." 4. Mr. Francis Fowke, "The First Discovery of the Comma Bacillus." 5. Exhibition of Nobert's original machine for ruling his lines.

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m. Annual Meeting.

Royal Society of Literature, 4, St. Martin's-place, W C., 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. C. S. Berthon, "Steel Guns."

THURSDAY, MARCH 12...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Chemistry and Physics Section.) Mr. W. K. Burton, "Recent Improvements in Photographic Development."

Royal, Burlington-house, W, 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 7 p.m. Prof. Ernst Pauer, "The Pianoforte Composers of Beethoven's time."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Dr. C. M. Campbell, "Physiology in Art."

College of Physicians, Pall-mall East, S.W., 5 p.m. (Croonian Lectures.) Dr. Hermann Weber, "Hygienic and Climatic Treatment of Consumption." (Lecture II.)

Royal Institution, Albemarle-street, W., 3 p.m. Prof. J. Dewar, "The New Chemistry." (Lecture IX.)

Telegraph-Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. 1. Sir David Salomons, "Constant Electromotive Force in an Electric-Light Circuit." 2. Mr. Andrew Jamieson, "Electrical Definitions, Nomenclature, and Notation."

Mathematical, 22, Albemarle-street, W., 8 p.m.

Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Mrs. Shiel, "Physiology and the Laws of Health." (Lecture III.). "The Muscles and Skin."

FRIDAY, MARCH 13...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. Mancherjee M. Bhownaggree, "The Present Condition and Future Prospects of Female Education in India."

United Service Institution, Whitehall-yard, S.W., 3 p.m. Mr. W. Anderson, "The Capabilities of Private Firms to Manufacture Heavy Ordnance for her Majesty's Services."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Sir Frederick Abel, "Accidental Explosions Caused by Non-Explosive Liquids."

Astronomical, Burlington-house, W., 8 p.m.

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. Wm. Kidd, "The Blasting and Removal of Rock under Water, and the Construction of a Deep-water Quay at Blyth Harbour."

Quekett Microscopical Club, University College, W., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

New Shakspere, University College, W.C., 8 p.m. Mr. Sidney L. Lee, "Shakspere's Comedies."

SATURDAY, MARCH 14...Royal Institution, Albemarle-street, W., 3 p.m. Mr. C. Armbruster, "The Life, Theory, and Works of Richard Wagner." With musical illustrations. (Lecture III.)

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Physical, Science Schools, South Kensington, S.W., 3 p.m. 1. Discussion on Professors Ayrton and Perry's paper, "The most Economic Potential Difference to Employ for Incandescent Lamps." 2. Mr. C. Cleminshaw, "Further Lecture Experiments on Spectrum Analysis."

Geologists' Association, 2 p.m. Visit to British Museum, Cromwell-road. Demonstration by W. Carruthers "On Cycads, Recent and Fossil."

Journal of the Society of Arts.

No. 1,686. Vol. XXXIII.

FRIDAY, MARCH 13, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURE.

The first lecture of the fifth course was delivered by Mr. J. Hungerford Pollen on Monday evening, 9th inst., the subject being "Carving and Furniture." The lecturer dealt with the principles of the wood-carvers' art, and described the various types of art, and the fashions which have been in vogue at different periods. The lecture was illustrated by a series of photographs of examples thrown on the screen by means of the lantern.

The lectures will be printed in the *Journal* during the summer recess.

ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal for 1885, early in May next, and they therefore invite members of the Society to forward to the Secretary, on or before the 18th of April, the names of such men of high distinction as they may think worthy of this honour.

The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, or Commerce," and has been awarded as follows:—

In 1864, to Sir Rowland Hill, K.C.B., F.R.S.

In 1865, to his Imperial Majesty Napoleon III.

In 1866, to Professor Faraday, D.C.L., F.R.S.

In 1867, to Mr. (afterwards Sir) W. Fothergill Cooke and Professor (afterwards Sir) Charles Wheatstone, F.R.S.

In 1868, to Mr. (now Sir Joseph) Whitworth, LL.D., F.R.S.

In 1869, to Baron Justus von Liebig, Associate of the Institute of France, For. Memb. R.S., Chevalier of the Legion of Honour, &c.

In 1870, to Ferdinand de Lesseps.

In 1871, to Mr. (afterwards Sir) Henry Cole, K.C.B.

In 1872, to Mr. (now Sir) Henry Bessemer, F.R.S.

In 1873, to Michel Eugène Chevreul, For. Memb. R.S., Member of the Institute of France.

In 1874, to Mr. (afterwards Sir) C. W. Siemens, D.C.L., F.R.S.

In 1875, to Michel Chevalier.

In 1876, to Sir George B. Airey, K.C.B., F.R.S., Astronomer Royal.

In 1877, to Jean Baptiste Dumas, For. Memb. R.S., Member of the Institute of France.

In 1878, to Sir William G. Armstrong, C.B., D.C.L., F.R.S.

In 1879, to Sir William Thomson, LL.D., D.C.L., F.R.S.

In 1880, to James Prescott Joule, LL.D., D.C.L., F.R.S.

In 1881, to August Wilhelm Hofmann, M.D., LL.D., F.R.S.

In 1882, to Louis Pasteur, Member of the Institute of France, For. Memb. R.S.

In 1883, to Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.

In 1884, to Captain James Buchanan Eads.

A full list of the services for which the medals were awarded was given in the last number of the *Journal*.

Proceedings of the Society.

INDIAN SECTION.

Friday, March 6, 1885: Major-General Sir Frederick J. Goldsmid, K.C.S.I., C.B., in the chair.

The paper read was—

THE TRADE BETWEEN INDIA AND THE EAST COAST OF AFRICA.

By Frederic Holmwood.

The East Coast of Africa and its immediate interior may be divided into three separate sections, the limits of which are determined by the coast line of the three powers which respectively rule them.

Commencing at the south, the British possessions extend from the Cape Colony in S. Lat. 34° to the southern limit of the Portuguese territory in S. Lat. 26°. Some doubt has recently arisen as to our rights on the

coast north of Natal; but, at the time our differences with Portugal regarding the possession of Delagoa Bay were submitted to arbitration, it was generally understood that our territory, or at any rate our protectorate, extended to Lorenzo Marquez, and it is unlikely that we shall withdraw our claims to any part of this coast.

The second section includes the Portuguese possessions of the Mozambique. It extends from Lorenzo Marquez to Tongy Bay, the southern boundary of the Zanzibar dominions in S. Lat. 10° 40'.

The dominions of Zanzibar form the third section. They extend from Tongy Bay to Warsheikh in N. Lat. 2° 20'. There is a stretch of Somali country reaching from this point to Cape Guardafui, but it is an arid surf-bound coast, unbroken by a single harbour, and it is never likely to become of any importance.

In regard to the first, or southern section of East Africa, the British colonies of Natal and Algoa Bay have now so small a trade with India, and are so little likely to increase it, that this district scarcely comes within the range of this paper.

The second section, which comprises the Portuguese possessions in East Africa, has a coast line of more than 1,400 miles; the seat of government, at the ancient city of Mozambique, is the headquarters of the Governor-General of the Province, who has a large staff of officials under him. A magnificent fort commands the entrance to the harbour, garrisoned by a considerable force of Europeans; and one or two Portuguese ships of war, with a few gunboats, are always present on the station. Lighthouses, a cathedral, and a number of imposing public buildings, give an air of importance to the place.

At Delagca Bay, Inhambane, Quilimane, and Ibo, there are lieutenant-governors with their staffs and troops, and, outwardly, everything would tend to impress the stranger with the magnitude of Portuguese interests on this coast.

In a colony like that of Mozambique, with such an extensive coast, possessing numerous commodious harbours and the sole navigable river in East Africa, which for centuries has been under the rule of a European Power, one would look for a considerable amount of development, and some signs that European civilisation had penetrated into the countries, and among the native tribes which have been so long in contact with the superior race—such as we find in connection with more recent colonisation in Cape Colony and Natal, but, unhappily, the reverse is the case.

Except on the immediate banks of the river Zambezi, Portuguese influence is absolutely confined to the coast, in fact to the few towns they actually occupy. Even on the Zambezi, Portugal holds merely a few isolated stations which, though giving her a right to the command of the river, have hitherto only served to close it practically to commerce, and to prevent the development of the adjacent country.

The Portuguese who colonise these stations are mostly of the penal classes, and engage in little more than than petty retail trade; and the official community have too generally regarded their temporary expatriation to Eastern tropical Africa as an opportunity for enriching themselves, by means which would only be tolerated in a country where public servants are left to pay themselves as best they may.

In short, the administration of this country is that of a penal colony in its worst aspects, and the consequence is that, instead of the cultivation of those friendly relations with the native population by which progress in such regions can alone be ensured, there is still, after centuries of occupation of the coast, so little cordiality between the settlers and the native races, that no Portuguese subject can venture more than a few miles from the walls of the towns, and trade is left almost entirely in the hands of a few foreign houses, who have to pay highly for the privilege.

The few traders who find their way to the coast are, perhaps, more attracted by the facilities for procuring guns and powder, the modern resources of the slave trader, than by any desire for intercourse with the white man, and the marked increase in the number of caravans which have reached this coast, since the success of our anti-slavery measures has limited the operations of slave dealers in the Zanzibar dominions, is very significant.

In order to pay her troops, and to prevent her colonial administration from breaking down, the home Government has been compelled to sanction the imposition of heavy differential duties and restrictive local imports, which have had the effect of checking all enterprise. Thus the fertile highlands of Upper Zambezi, and the fine country on the southern shores of Lake Nyassa, which Portugal claims to include in her territory, have been wholly neglected; while those who would have utilised these dis-

tricts have been shut out from all chance of doing so.

It is true that the Mozambique coast is the most unhealthy portion of Eastern Africa, but there would be no lack of British Indian traders ready to act as intermediaries between European and native, could they see a reasonable hope of enjoying protection for their persons and property, and feel any confidence that they would not be overburthened by taxation, and other restrictions affecting freedom of trade.

The bulk of the Mozambique trade has long been in the hands of French houses, though during the past five or six years British and German firms have taken some share in it. The tariffs and local dues, however, have proved prohibitive to our merchants, who have now almost entirely withdrawn from the country; but the Germans, having virtually secured a monopoly in the trade in firearms and gunpowder, have made great progress, and are likely to wrest a considerable proportion of the trade from the French.

During the past few years, a remarkable demand has set in, in favour of Indian cottons, which, for a time, seemed likely to supplant all other plain manufactured goods in this market. This was owing to the natives discovering that they combined durability with lowness of price. As, however, the Mozambique tariff included them with fine cotton cloths, on which the duty is levied by weight instead of *ad valorem*, Indian cottons have scarcely been able to hold their own, and a special tax placed upon them in 1882 would effectually have shut them out from this new market, but for the action of our Foreign-office, which was successful in causing the removal of this impost. The promising trade, however, which had induced several British firms to open branch houses at Mozambique, seems to have received a severe check, for these firms have recently followed the example of British merchants, and withdrawn their agents.

I did not, unfortunately, receive notice of this meeting in time to procure reliable statistics of the Mozambique trade but there would be little utility in giving figures; unless they were some guide to the future, and the future of the trade between India and this coast must necessartly depend entirely on the policy Portugal may pursue in regard to her colony.

Events are now taking place, however, which may shortly alter the position of trade on the Mozambique coast. It may be hoped that one of the effects of the Berlin Conference will be to neutralise the River Zambezi, and that the feeling shown against differential duties, in dealing with the Congo question, may warn Portugal to adopt a more liberal policy in her East Coast possessions. Already an influential company is forming for the purpose of opening up the Zambezi, and its success would be certain to favour the operations of British Indian settlers on that river, while it would probably open new markets for Indian manufactures. On the whole, therefore, we need not be without hope for the future of our commerce in this part of Africa.

There is a circumstance in connection with this region which deserves passing notice as having some special bearing on India. Some few years since, it was found that the soil of certain places on the banks of the Zambezi appeared peculiarly suitable for the growth of opium. A Portuguese gentleman, one of the few who have shown anything like enterprise on this coast, founded a company, and undertook the culture of this product. He proceeded to India, and engaged a number of skilled hands from the Malwa district. From the samples of the drug which was manufactured during the first two years, there was reason to believe that the new industry would prove a great success, and the experiment was watched anxiously by the Government of India, who foresaw how seriously it might affect Indian revenue; but the Indian workmen shortly found that they were unable to stand the humid and malarious climate, and declined to remain in the country. From that time the enterprise has steadily declined, from want of dexterity on the part of the natives who were trained to replace the Indians.

In event, however, of the Portuguese departing from their traditional obstructive policy, the experiment referred to is likely to be renewed on a far larger scale, and those interested in India must not, therefore, lose sight of the practical effects which would follow the success of such an undertaking.

This section of East Africa has, since 1873, enjoyed every advantage which regular means of communication with Europe and India could afford. Owing to its position, the two lines of steamers subsidised by our Government for carrying the Zanzibar mails, *viâ* Aden and the Cape respectively, have necessarily touched at Mozambique and the principal ports in Portuguese territory, and the line of telegraph between the Cape and Aden also communicates with these stations.

It may be here appropriate to make a brief

reference to Madagascar, which lies exactly opposite the Portuguese territory on the mainland, at a distance of only 250 miles to the eastward. This island is more than 1,000 miles in length by about 300 in breadth, and its position, as well as its connection with Indian trade, requires that it should not be entirely passed over in this paper.

Indian settlers and traders have for a considerable period resided in all the principal towns in the north of Madagascar, from Tamatave on the east coast to Cape St. Andrew on the west; and, during the past few years, these British Indian colonies had been everywhere increasing. They were rapidly opening up the trade of the country, and, as in Mozambique, Indian cottons were showing a tendency to supplant those of other manuacture; and several large Bombay and Zanzibar houses, seeing the future importance of the trade, had commenced to establish agencies at the principal ports. Recent French action in this island has, however, entirely frustrated all their hopes, and it has completely ruined their trade.

In common with American, German, and British merchants, they have been compelled to withdraw their agents, or have left them to wind up, as best they may, the wreck of what seemed so promising an enterprise.

It is possible that eventually, when the country becomes settled, trade may revive, but, judging from experience, it is to be feared that there will be little hope for the future of our commerce in Madagascar, should the island become, as probably it will, virtually a French colony.

We must now turn from the somewhat disheartening spectacle which is presented by the regions included in the sixteen degrees of south latitude above described, to a consideration of the third section into which, for present purposes, this side of the African continent has been divided; and here we shall find a far more hopeful prospect, and one especially connected with British Indian interests.

The dominions of Zanzibar comprise a coast line of 1,050 miles, exclusive of the islands of Zanzibar, Pemba, and Mafia. Zanzibar, the capital, is a city of about 100,000 inhabitants. It is situated on the island of the same name, which is a perfect garden of cloves, cocoanuts, and tropical fruits, 58 miles in length, by upwards of 20 in breadth.

The harbour of Zanzibar, which is both safe and commodious, is situated on the western side of the island, about 20 miles from the mainland. Its northern approach is already lighted, and works are in progress for lighting the southern entrance, as well as for supplementing the lighthouses to the north.

The island of Pemba, 30 miles to the north, is one vast clove plantation; its annual export of cloves has recently averaged a quarter of a million sterling in value. The principal ports on the mainland are Mikindani, Lindi, Kilwa, Dar-es-Salam, Bagamoyo, Saadani, Tanga, Mombasa, Malindi, Lamo, Kismayu, Brava, Marka, and Magdisho. These towns have a population of from 4,000 to 15,000. With the exception of the four last named, which are on the Somali coast, they all possess fine harbours.

Except along the trade routes to the interior, where Zanzibar territory extends inland for more than 700 miles, the depth of the country actually under the rule of the Sultan does not exceed about 50 miles, but many of the native tribes beyond this limit acknowledge the ruler of Zanzibar as their suzerain.

The government of Zanzibar is an absolute monarchy, but, from causes which will be apparent when we come to consider the position of the various treaty powers, this form of government leads to very few abuses, and both civil and religious freedom are enjoyed by all classes, in a degree that even few European countries can boast of.

The Sultan, Sayyid Burghash bin Sa'eed, succeeded his brother Sayyid Majid, in 1870. He is an able and enlightened ruler, and, could he be induced to see the great future importance of his territory on the mainland, his power and influence would become immense. Recently, he has entirely dispensed with ministers to assist him in his government, having experienced the danger of trusting to Eastern advisers, in whose hands he was never safe from intrigue, and, with the exception of Sir John Kirk, the British representative at his court, he has seldom allowed Europeans to influence him, having found, in cases where he has done so, that he was liable to be misled for private ends. He is well aware, however, that the interests of Great Britain on this coast are bound up in his independence and the prosperity of his rule, and that our Government would willingly sanction nothing that is not likely to conduce to his welfare and that of his country.

There is, at present, no definite law of succession to the Sultanate, and this must necessarily give rise to considerable anxiety for the future, both to his Highness and ourselves, who

have such important interests and so immense a stake in the country. It would not, however, be impossible to make an arrangement which would meet this difficulty, and it is important that so serious a danger should no longer be allowed to continue.

The population of the Zanzibar dominions consists of Arabs and free natives, the proprietors of the soil, of emigrants from the Comoro islands, Persia, Syria, and Egypt, and of slaves. The latter comprise fully two-thirds of the whole number, but this proportion is rapidly decreasing through the effects of our anti-slavery policy.

The foreign population includes British, French, German, American, Belgian, and Italian subjects, each under the rule of their own representative, and subject to the jurisdiction of their Consular Court, unless in cases where they are plaintiffs in a suit against a Zanzibar subject.

The following table gives the number and nationality of the foreign residents in Zanzibar in 1874 and at the present time :—

British Subjects Residing in the Zanzibar Dominions.

	1874.	1884.
British born subjects	24	89
Khojas (Mohammedans)	2,725	3,250
Bohras ,,	543	1200
Memonds and Scindis ,,	116	320
Hindus (Banyans)	814	1,050
Parsees	0	60
Goanese	59	650
Total	4,281	6,619

	1874.	1884.
French residents	15	39
German ,,	9	13
American ,,	6	8
Belgian ,,	0	5
Italian ,,	0	2

The position of foreign residents in the Zanzibar dominions is regulated by well defined treaties, which render trade as free as in Great Britain, and secure advantages to the settler and purchaser of land, houses, and other property, such as are unknown in any other country in the world.

The powers which have entered into such treaties are England, France, Germany, and America, but the rights and privileges secured to them are practically enjoyed by the subjects of all the other powers.

These treaties concede the right to purchase or rent both movable and immovable property in all parts of the country, and the property thus acquired or occupied is free from all taxation whether general or local.

The Sultan's officers, moreover, can only enter such premises or interfere with such property by permission of the representative of the country to which the owner or occupier belongs. No subject of a treaty power can be arrested except at the instance of his Consul; on the other hand, the Sultan affords to the foreigner protection both to person and property. Foreigners have the right to travel or settle in any part of the dominions, and to exercise any religion they may please.

And, lastly, the subjects of treaty powers are at liberty to engage freely in trade of any kind, whether import, export, or local, and they may be subjected to no hindrances when buying, selling, or bartering with subjects of Zanzibar. They are liable to no duties or taxation, harbour, clearance, or light dues, in fact to no impost whatever, either direct or indirect, with the exception of an *ad valoram* duty of 5 per cent. on imports. The Sultan, however, has reserved the right to levy special duties on ivory and gum-copal on that portion of the coast situated between the ports of Kwale and Tanga, a very small proportion of his dominions.

In the following statistics of Zanzibar trade, the totals of imports and exports may be taken as being considerably below the true value; for, owing to the absence of customs returns, it is not easy to check the statements of the farmers of the revenue who, in consequence of the periodical sale of the customs contract, are naturally interested in giving as low an estimate as possible of the trade of the country.

It is impossible to carry the statistics of general trade beyond 1880, but those of the trade between India and Zanzibar can be given up to 1883.

Twenty years ago, when the slave trade was at its height, and for several years after that period, the imports averaged £500,000, and the exports £420,000.

On the 5th June, 1873, Sir John Kirk negotiated a treaty with the Sultan for the abolition of the slave trade in Zanzibar waters, which effected a complete revolution in the trade of the country.

The two or three following years may be considered as a transition period, during which commerce was gradually accommodating itself to the altered conditions, consequent on the sudden withdrawal of British capital from the slave trade.

The total imports for 1873-74 amounted to £395,252, and the imports to £276,150. There is no official record of the trade of the two following years, but we know that, though trade did not completely recover from the depression referred to, British capital had already commenced to develop those new resources which Sir John Kirk had pointed out as being far more profitable than the slave trade, and the exports for the first time exceeded in value the amount of imports.

During the next four years trade not only completely recovered itself, but actually doubled; and even the Arabs acknowledged that events justified our action in regard to the slave trade, so far, at any rate, as it affected the prosperity of the country. The trade of those years was as follows:—

IMPORTS.

1876-77.	1877-78.	1878-79.	1879-80.
£	£	£	£
696,925	688,950	709,900	870,000

EXPORTS.

1876-77.	1877-78.	1878-79.	1879-80.
£	£	£	£
921,920	1,022,750	870,350	1,150,000

In regard to the shipping entering the port of Zanzibar, it may be noticed that in 1879, 69 British, 4 French, 13 German, and 10 American vessels were entered, having an aggregate tonnage of 89,463. Twenty years previously, in 1859, only one British vessel, of 493 tons, was entered at the port; while 12 French, 17 German, and 35 American vessels (including whalers), having a tonnage of 18,200, were entered. These figures are exclusive of ships of war.

There are now not only two lines of mail steamers monthly to Zanzibar, but also three lines of steamers connecting that port with India—that of the British India Company, running between Bombay and Zanzibar, *viâ* Aden, and direct lines, between Bombay and Calcutta respectively, of steamers belonging to his Highness the Sultan. This competition has reduced freights to rates which are almost nominal; and though it may be doubtful whether this does not tend to over-trading, and whether in some other respects it is an unmixed good, it is certain that it greatly favours trade between India and Zanzibar, and that it will obtain for Indian manufactured goods a position in East African markets which they would never otherwise have secured.

In connection with Zanzibar shipping, it may be mentioned that, besides the large number of Arab craft trading between Zanzibar and India, Mozambique, and Madagasgar, there are now 270 native vessels owned by British Indians, having an aggregate tonnage of 8,100.

We must now specially consider the trade between India and the Zanzibar dominions, and the following statistics will show at a glance how large a proportion of the whole trade of the latter is absorbed by India.

Owing to the fact that the Bombay Customs returns up to 1878 included the trade of Mozambique and Madagascar with that of Zanzibar, it is only possible to give reliable statistics from 1879 to 1883 inclusive; but these will be found amply sufficient for comparison with the general statistics already given:—

TRADE BETWEEN ZANZIBAR AND INDIA.

	1879.	1880.	1881.	1882.	1883.
	£	£	£	£	£
Imports	252,805	316,374	434,263	346,250	470,420
Exports	175,997	280,156	251,837	267,495	285,438
Total trade	428,802	596,530	686,100	613,745	755,858

Official years ended 31st March.

It is impossible to institute an exact comparison between the above statistics and those of the general trade of Zanzibar, because the former are made up to the close of the Indian official year, while the commercial year in Zanzibar coincides with the Persian "noroz," which ends about 22nd August. But the discrepancy thus caused cannot seriously affect the conclusion to which such a comparison points, namely, that for the years 1879 and 1880, more than one-fourth of the whole trade of the Zanzibar dominions was with British India. The imports of Indian merchandise far exceeded this proportion, while the exports of produce were slightly below it.

Although there are no official records of the general trade for the years 1881, 1882, and 1883, we know that there was a considerable falling off, especially in the latter year, but the special trade with India, it will be seen, did not share in the general depression; on the contrary, there was a marked increase, and it may be safely concluded that, for these three years, one-third of the whole trade of Zanzibar was with India.

No doubt a considerable part of the imports

consisted of British manufactures, and that a portion of the exports found their way to British markets; but, both in Zanzibar and India, they passed through the hands of British Indian merchants, helped to develop the shipping trade, and contributed towards the revenues of both countries.

The details of the various products and articles of merchandise exported and imported by Zanzibar would require an amount of space that cannot be afforded in this paper, but the subject is one of deep interest to all who are watching the development of the African continent, and I should have been glad had time permitted me to enter fully into it.

Little is known by the general public as to the nature and application of the vast shipments of produce which are exported from this part of East Africa, and I would venture to suggest that, in view of the intimate connection between India and this coast, and the fact that, so far as it is a commercial country, Zanzibar is virtually a British Indian colony, it might be appropriate to organise a Zanzibar annexe in connection with the Indian Exhibition, which is to take place at South Kensington, in 1886. Here these products could be exhibited, and their uses explained in a practical manner, and there is much in regard to them which would prove deeply interesting, even to the best informed. If these were supplemented by living types of the several native tribes, together with specimens of their habitations, dress, arms, ornaments, and other articles illustrative of their manners and customs, and of the way these have been affected by the progress of European and Indian trade, such an addition to the Exhibition would prove as popular and attractive as it would be instructive.

The above statistics, conclusive as they are as to the rapidly increasing importance of the trade of Zanzibar, convey but a very faint and partial impression of the magnitude of British interests in the Zanzibar dominions.

In order to arrive at a true estimate on this point, it will be necessary briefly to review the whole subject of our connection with Zanzibar, and especially the position which our Indian subjects hold, and are likely, in future, to occupy there.

Going back twenty years, to a period when the slave trade was at its height, and a recognised institution in the country, the trade of Zanzibar was, as we have already seen, less than half what it is at present; while a large proportion of it, including nearly the whole of the shipping trade, was in the hands of French, American, and German merchants. At that time, the Indians, though under our protection, looked to their connection with the slave trade for a profitable investment of their capital.

In 1873, the slave trade in Zanzibar waters was declared illegal by treaty, and the repressive measures which we adopted, compelled the British Indians who had hitherto supported this traffic by financial aid, to withdraw their capital entirely from the now illicit trade. The consequence was that the markets became glutted with cotton goods, beads, and other merchandise for which there was no demand, and the Arabs, who were heavily in debt to the Indian merchants, declared themselves unable to meet their liabilities. At the same time the thriving clove plantations, on which the Indians had made advances to their full value, seemed likely to become absolutely worthless. Under these circumstances, it is not to be wondered at that there was considerable discontent and murmuring against our Government, and that the Arabs and our subjects declared that they were irretrievably ruined.

At this juncture, there is no doubt that the Indian population, who represented the whole wealth and importance of the country, were on the point of separating themselves from our jurisdiction, and of seeking the protection of Arab and French rule, but Dr. Kirk (now Sir John Kirk), the British consul, who was greatly respected by all classes, was successful in making use of his influence in so directing the revolution thus caused in the customs and commerce of the country as to permanently establish our paramount influence, which was so nearly threatened with extinction.

Foreseeing the future importance which the great capabilities of the country must ensure, when capital was transferred from the now illegal slave trade to the development of legitimate commerce, he gathered round him the wealthy leaders of the Indian community, and succeeded in convincing them that the prospect was far from being as dark as they anticipated.

By appealing to their loyalty, giving his active support in arranging the difficulties in which our action had placed them, and, above all, by promising them the full benefit of that protection which they saw would be so much more essential now that they had to rely on legitimate trade, he induced them to make arrangements which enabled both the Arabs and the smaller Indian merchants to tide over the present crisis, and thus saved the general

credit from collapsing until new enterprises should have time to work the revival he predicted for them.

After three years of depression, he had the satisfaction of seeing trade revive, and increase more rapidly than even the most sanguine had ventured to hope, and to find the new products he had brought to the notice of our merchants becoming staple exports, repaying to our subjects tenfold the amount of the losses they had sustained through giving up their complicity in slave dealing. It was, doubtless, an equal satisfaction to the Sultan to find that his revenue had become more than doubled by the same causes.

But though events may have fully justified our action in forcing our anti-slavery policy on the country, we are not therefore under less responsibility, either to the ruler we coerced, or to the British Indian community who so loyally supported us. By acceding to our wishes, his Highness undoubtedly incurred the enmity of his subjects, and he has a right to our support so long as we continue to exact the fulfilment of the treaty we imposed upon him.

In the meantime, the Indian population has become an important and loyal British colony, domiciled with their families in the country they have adopted, and having an immense capital invested in land, house property, and commerce. The whole trade of the country is theirs, or passes through their hands, the caravans proceeding to the interior are their ventures, and the Arab leaders their agents.

There can be little doubt that, eventually, slavery will be wholly abolished, and it will then be necessary for our Indian subjects to assume the cultivation of the vast clove and other estates which are actually or virtually their property. The necessity for the introduction of Indian coolie labour will then occur, and the islands of Zanzibar and Pemba alone would probably absorb about 250,000 labourers, and there is no practical limit to the number which the development of cultivation on the mainland might employ.

It may be anticipated that when this time arrives, the immense advantages which such a class as the Indian coolie class would have in a country where no rates or taxes could be imposed on it, will induce a considerable emigration from India. If this conclusion be a correct one, the serious nature of our responsibility in regard to the future of the Zanzibar dominions cannot easily be exaggerated, and it must be incumbent on all who are interested in the welfare, both of India and East Africa, to give their careful consideration to what any diminution of our paramount influence in these dominions may lead.

At present everything may appear hopeful, but, in view of the present feeling in Europe with regard to Africa, we must not lose sight of the fact that the status of our important colony at Zanzibar is unique, for though living under British rule, they are residing in a foreign country under an independent ruler, and anything affecting his independence must react disastrously on their position and on our prestige.

In conclusion, a few remarks concerning the inland regions contiguous to Zanzibar territory may not be inappropriate, though not, perhaps, bearing directly on the subject of this paper.

It has been seen that the dominions of Zanzibar penetrate inland only along the line of the principal trade routes, and it will, therefore, be apparent that there must be a vast extent of undeveloped country lying between the lakes of Central Africa and the Coast.

The ravages of the slave trade, however, have so depopulated the greater part of this region, that it has to a large extent become a wilderness, and, whatever its natural capabilities, the want of population must render any future resuscitation of the country an extremely slow process.

There is, however, a vast country situated immediately beyond the northern half of the Zanzibar dominions which may, at no distant period, rival the finest of our Indian provinces. This is the mountain district of Kilimanjaro, recently explored and described by Mr. Joseph Thomson as far west as the shores of the Victoria Nyanza, and the region north of it, which stretches towards the confines of Abyssinia. Owing to the fierce character of the tribes who occupy that part of it adjacent to the coast, this country has hitherto been almost closed to trade, but it is believed to be richer in ivory, and probably also in mineral wealth, than any other part of Eastern tropical Africa. It includes vast tracts of pasture land, the grazing ground of innumerable herds of cattle, and these are situated so near the coast that the opening up of the country might be expected, by developing the trade in hides alone, to add materially to the exports from the Zanzibar coast. But the greatest advantage possessed by this region is that it consists, to a great extent, of healthy uplands, having an elevation of from 4,000 to 9,000 feet above the sea level,

which, being well irrigated by nature, are adapted for the cultivation of wheat, coffee, cinchona, tea, and other valuable products, to a practically unlimited extent.

A considerable portion of this country is suited for European settlement; and only 140 miles from the port of Mombasa and Tanga, nearly opposite the island of Zanzibar, is an elevated plateau, on the slopes of the snow-capped mountain of Kilimanjaro, which supplies a convenient sanatorium, the want of which has been so great a drawback to this coast.

This region needs further exploration, pending which, it is impossible to say definitely how far capital may be safely employed in developing it; but in view of the movement in favour of African annexation, which is so rapidly increasing among European nations, I have recently, on several occasions, both public and private, advocated the construction of a railway from the coast to the mountain region referred to.

It would be out of place here to enter more fully into this subject, but for the sake of our large manufacturing trade, both British and Indian, as well as for our Imperial interests generally, it may be hoped that all action in this direction will not be delayed until it is too late.

DISCUSSION.

Mr. J. M. Maclean said that, for the last seventy-five years, since the English succeeded in expelling other nations from India, we had had the control not only of the trade of India, but of all the countries bordering the Indian Ocean, and the influence of England had practically been supreme on the eastern coast of Africa. It was a gratifying reflection, therefore, that that influence had been turned to exceedingly good account in the dominions of an independent prince like the Sultan of Zanzibar, so that that equal treatment had long been afforded there to foreign nations, which was apparently supposed, at the late Berlin Conference, to be an entirely new principle in African affairs. England was not only a great European but a great Asiatic power; and it was a fallacy to imagine that the natives of India themselves had no enterprise which carried them beyond the seas. Practically, from time immemorial, it might be said that Indian capitalists had controlled the trade in the countries round the Persian Gulf, and in Arabia, and they had done a great deal to bring out the trade in the countries along the eastern coast of Africa, and to promote free intercourse across the Indian Ocean. We had great responsibilities towards the natives of India who had settled in those regions, and it was sincerely to be hoped that those responsibilities would not be overlooked. Probably, the main business of maritime enterprise in the present age, as managed by Europeans, was the opening out of Africa, much as America was opened out two centuries ago, and as, later, India and China were opened out by English and other European adventurers. In one way and another, the whole continent of Africa was now being opened, and it was certainly incumbent upon Englishmen that they should not allow themselves to be beaten in the race in any part of Africa. Some little time ago a paper appeared in the *Pall Mall Gazette*, written by an Englishman who had travelled along the East Coast of Africa, and it was surprising to find from it how the Germans were everywhere supplanting us in trade, and pushing themselves forward in all parts of that continent. Only within the last few days a German company had been announced, which was intended to explore and develop the resources, for the benefit of German trade, of that part of the continent of Africa which Mr. Holmwood had described as lying to the north-west of the dominions of the Sultan of Zanzibar. English merchants would have something to reproach themselves with if they allowed the German merchants thus to take precedence of them; and it would to that end be of great advantage if gentlemen like Mr. Holmwood, and distinguished geographers—such men as Mr. Stanley, and others—instead of reading papers to learned societies, would go before the chambers of commerce in London, Manchester, Liverpool, and other places, and tell them how necessary it was for Englishmen in these days to be up and doing, if they wished to maintain their commercial supremacy in various parts of the world. Although it might seem a paradox to say it, he had often thought the electric telegraph had had some effect in paralysing the activity of English merchants. Twenty-five years ago the merchants of Bombay, it might be said, were a very different class of men to those now engaged out there, although of course he did not in the least desire to make any reflection on those gentlemen. Certainly, in the old days, before the electric telegraphs were in existence, English merchants had great responsibilities entrusted to them; they felt the obligations imposed upon them; they made their homes in the countries they went to, studied the habits of the natives, and ascertained how English trade could best be adapted to the new markets, and the wants which required to be supplied. They really took the initiative in advancing and expanding trade wherever they went. But, now-a-days, men stopped at home in their easy chairs, in offices, within sound of the perpetual tinkling of their electric bells, and they thought the attention of clerks was quite sufficient to manage their interests abroad. And now they were experiencing a pretty smart awakening, for they found that orders were not coming so frequently to them from all parts of the world, but that it was necessary for them to use their

best ability to open up new markets, and to prevent the old markets from being closed against them. That was the kind of interest which ought to be seen reviving in English trade, and there was certainly an immense field along the East Coast of Africa, in which it might find development. Complaints were constantly heard from manufacturers, especially in Lancashire, that English trade was not expanding as it used to do; and the remedy for it was for merchants to try a little enterprise on their own account. How many fruitless expeditions had we seen of late years? Immense expenditure was made upon the expedition to Abyssinia, where a large army marched into the country, and after rescuing a few persons, simply marched out again, without any attempt being made to open a new market there. The same thing had occurred again in Central Asia, and we were doing the same now in the upper regions of the Nile. Why did not our merchants send their representatives with our armies, to try and take advantage of these great military undertakings? Possibly these remarks went somewhat beyond the subject of the lecture, but they had been suggested by what Mr. Holmwood had so well said. Englishmen need not be afraid of competition anywhere, if they would only display the old spirit of enterprise which had made this country what it is.

Mr. MARTIN WOOD, referring to the past connection with Zanzibar, which had long been a household word in Bombay, said although the distance to be traversed across the ocean was great, that distance was not so great an obstacle, owing to the trade winds. The chairman was well aware of the connection politically with the Bombay services in former years. Men who had acquired a proficiency in Arabic had gone to Zanzibar, and many eminent officials who had been ornaments to the Indian services had added to the repute of the British name in those regions. Again, as had been so fully shown in the paper, a large portion of the commercial population of Western India had been accustomed for generations to trade there, and many of them had carried commerce to the ports of the mainland. Referring back to that older time before there were any troubles in Zanzibar, and before Sir Bartle Frere and Sir Lewis Pelly went there to overthrow the slave trade—Mr. Holmwood had quite correctly attributed to Sir John Kirk the final abolition of the slave trade, but it was not done until after the expedition of the two eminent men he had mentioned—before that time there was a long period of quite regular intercourse between Western India and Zanzibar. Except for occasional difficulties arising in connection with the dynasty and affecting the Sultan himself, year after year things went on in the quiet way which had been so well described in one of Sir Bartle Frere's pleasing narratives in *Macmillan's Magazine*. Then there came a catastrophe in Zanzibar—the cyclone which destroyed all the plantations on the islands, a calamity which had marked an era in the history of the country. Livingstone also made another interesting connection between Western India and Zanzibar, for each time he went to Africa he went round by Bombay, which he left in 1866 on his last journey. Thus the paper had called up in the minds of Mr. Maclean and himself many traditions presenting deeply interesting reminiscences; but, he quite coincided with that gentleman in saying that many things in the history of Eastern Africa showed the supineness and indifference of Englishmen in its prosperity, and in utilising those outlets for trade which were ready to our hands, taking Bombay as a centre. For Bombay was, so to speak, the base for the trade of Eastern Africa, though of late years steamers had been going directly through the canal, and had somewhat altered the course of trade. With regard to the northern coast up towards Cape Gardafin, Mr. Holmwood had referred to it as being desolate, with scarcely any harbours. It was a very dangerous coast in certain times of the year, on account of the fogs with which it was enclouded in the south-western monsoons, and nearly every year several vessels were lost there, the value of any two or three of which would suffice to build a lighthouse. In that respect the authorities had been guilty of the most deplorable neglect. This was a matter which should not be longer overlooked, as it had now a special connection with our Zanzibar trade.

Mr. HYDE CLARKE said, on this subject, which united the African and Indian Sections of the Society, many important topics had been brought forward which it was to be hoped would attract public attention when they appeared in the *Journal*. In reference to the enterprise of our merchants, it was a true indictment against them that they had been very greatly wanting, he would not say simply in enterprise, but in intelligence on these subjects, but at the same time there was something to be said with regard to other parties who were to blame in the matter—he referred to her Majesty's Government. If there had been the same spirit shown by the officers of the Government as by individual Englishmen on many occasions, we should not have been in our present unfortunate position. The responsibility for it had been shifted from the Government to the mercantile community, and from the mercantile community to the Government, but it was clear that the united energies of the nation must be brought to bear on the present crisis—the responsibility could no longer be shifted, and the necessity for exertion could no longer be put aside. Efforts had not been wanting on the part of many individuals as well as associations to propagate information on this subject, and Manchester had for many years taken a very deep interest in obtaining and diffusing information with regard to the extension of our trade. That had been done by Mr. Stanley, Captain Cameron, and by others who had gone about the country to chambers of commerce, giving them information and urging them to take advantage of it? After all, it was not so

much German enterprise as German intelligence which was, to a certain extent, supplanting us. With regard to the relations between the Bombay population and the populations of Western Africa and Zanzibar, a peculiar advantage existed in reference to intercourse with natives on the part of our Indian people. A German's first step was to make himself acquainted with the language of the people he went amongst, and in doing so he was greatly assisted by the German system of teaching. It was a great shame to us that, in this vast metropolis, without referring even to our other commercial centres, there was no public school for the teaching of living languages, such as they had in Germany and France, and which would, undoubtedly, be one of the main things enable our young men to compete in commerce with young Germans. We were not wanting in enterprise, and had always been at the head both in that and in exertion. It might be thought that Mr. Holmwood had, to a certain extent, trespassed in applying the term "colony" to our Zanzibar *protegés*; but they should refer back to what were called the "factories" in the earlier periods, at the commencement of our colonising efforts in India and elsewhere throughout the world. As far back as the Elizabethan period, wherever Englishmen were planted, factories were constituted; and the factories which were established in India and in the eastern seas, laid the foundation of our empire there. In other places the factories remained to this day distinct English communities with English institutions and English laws, and they were models from which this institution in Zanzibar was taken. He had lived in a factory dating from three centuries. Mr. Holmwood's remarks on that point were of especial importance at a period when we were called upon to recast our whole Colonial policy; when, in some cases, we were having new forms of international law and of processes of possession imposed upon us which would deprive us of the labours of our predecessors, it was time to consider the whole subject, and it would be of great advantage to consider this subject of the establishment of factories in connection with Zanzibar in view of next year's Exhibition. Their Society, which might almost be considered the author of exhibitions, might very well (through this Section) take into consideration the means of carrying out Mr. Holmwood's proposition. Looking at it in a historical light, it was by no means forcing the position to place the productions of Zanzibar alongside those of many distinct English colonies. By including in the Exhibition what some chose to call colonies, but which might be accepted rather as factories, a good and useful thing would be done. It was of the greatest importance that Englishmen should recognise our relations with Zanzibar, and more particularly in connection with our German friends. He spoke in no hostile spirit of, but had always advocated closer alliance with Germany, and to profit by their devotion to our language and literature, and to take equal care on our part in cultivating them, and he believed it was through our failure to recognise Germany's present position that our difficulties had arisen throughout the Continent of Africa. But it was a hard thing that, after we had discovered and developed the Lake countries in the neighbourhood of Zanzibar, after we had traced out the course of the Congo by the labours of our explorers, missionaries, and traders, having thus created a field for enterprise, and when we were beginning to occupy that field, others, who had done nothing for the cause of progress, should come and take from us the reward of those labours. So far from our merchants altogether wanting enterprise, many in London and elsewhere were at present endeavouring to extend their trade in those two regions, the Lakes and the Congo, and they were now cut off by the supineness of our authorities. The higher Lake countries of Africa offered a most important field for extension, from their upland and healthy position, and intelligence with regard to those regions should be propagated. It was lamentable that, after all that had been done in the provinces and colonies by geographical and commercial societies, the British Commercial Geographical Society should have been allowed to languish in London. This was matter which should not be left entirely to the exertions of the merchants, and it was necessary that our statesmen and public should be made aware of the value of these countries, and of the extent to which their resources could be developed. It appeared monstrous that the trade of the vast Congo country should have been handed over, almost without a thought, to the Portuguese. Even in the late Berlin Conference, while giving so much to the Portuguese upon the Congo, we had not asked them, as we might have done, for some freedom of intercourse with the Mozambique territory. If not alone our merchants and the public, but our statesmen, possessed a greater degree of intelligence on these matters, we should not see our opportunities thrown away, our colonial position jeopardised, and our Indian empire placed in danger.

Mr. LIGGINS said one very difficult question upon the subject of free trade, in the connection of such a colony with the outer world, was to know by what means they were to obtain their necessary revenue. When the West Indian Colonies were asked by Government to give up their import duties, they refused, with all regard to free trade principles, because they did not see their way to legitimately raise a revenue upon anything else. Information how to do that would be of the greatest value to the old colonies under the British crown. With regard to the slave trade, they had lately been horrified at the result of some of our operations in that direction on this coast, and he would like to know how it was that our naval force had been so diminished that when a British man-of-war was chasing a slaver the other day the poor creatures could not have been saved

from being thrown overboard. When the slaver was captured she had no crew on board, and of course no one could be punished for that most barbarous murder. On the point of the withdrawal of the Post-office contract from Zanzibar, if true, it was the most disastrous thing that could have been done. If Government would not support the trade opened by the enterprise of British merchants, it was not likely that people in England would care to invest their capital in a place from which they could expect no relative return. Nothing was more discouraging to our merchants than that they should have to rely upon foreign steamers. But it was always the same wet blanket which was thrown over our trade, a system creating of course the greatest irritation and disgust. If that course were to be pursued, how could the trade of England be expected to increase? He would also ask what was the effect of the climate of these countries on Europeans.

Mr. Holmwood, in reply to the first question asked, said, only one import tax could be levied by the Sultan, and that was an *ad valorem* import duty of 5 per cent., and it would be utterly impossible for the Government of the Sultan to go on if that tax were withdrawn. The revenue derived by the Sultan from the customs duties was about £200,000 per annmm; but as yet only a small part of the coast had been developed. With that £200,000 the Sultan paid his troops, and had undertaken some very important public works. Some revenue also was derived by the Sultan from his private plantations, and until lately he had almost entirely devoted it to the public good. Five or six steamers which he had bought from the P. & O. Company, were now being run in the trade between Calcutta, Bombay, and Zanzibar, and they brought over grain which was sold at Zanzibar at the same price as it cost in India, the Sultan thus defraying the cost of transport out of his private resources. Beyond that sum —about £250,000 altogether—there was no revenue whatever for developing the country, and that was why he so strongly advocated that British merchants should provide the capital necessary for that purpose. With regard to the second question, it was true that one of the British men-of-war (H.M.S. *London*) had been withdrawn from Zanzibar, but that vessel was in a rotten state, and having become dangerous to the lives of those on board, the Government could not have done better than remove her. However, the Sultan had been so loyal to his undertakings, that except for some small smuggling traffic, the trade in slaves, by the running of the slave dhows, had been absolutely abolished, so far as Zanzibar waters were concerned, with the accompanying terrible and atrocious scenes. He did not believe the Government had revoked the mail subsidy, certainly the Foreign-office had not in any way given its consent to that withdrawal, and he could not think the statement was accurate. With regard to the climate, he had been in the country for twelve years, and it certainly was trying, and people out there required change, but the prevalent ideas relative to East Africa on that score were very much exaggerated. No young Englishman or European who kept moderately steady need fear the climate in the least; and fathers need not hesitate to send out their sons, always providing, of course, they were free from organic disease. There was no very great heat, and no very great variations, but of course long residence out there to a certain extent "took it out" of Europeans. He might mention, in regard to a remark which had fallen from one of the speakers that evening, that he had long since proceeded to Manchester and had been before the Chamber of Commerce, and had spoken, both publicly and privately, at the Geographical Society there, and at various meetings, and he had endeavoured to impress upon them how necessary it was for Englishmen just now to be up and doing, especially in East Africa, if they wished to maintain their commercial supremacy. It now only remained for those who were practically interested in commerce to do their share towards this important object.

The Chairman thought it would be difficult to say much on the subject without going again over the ground already covered. One of the most interesting points in it was the position of the large group of native merchants who, we must feel, were British subjects. We had very heavy responsibilities in connection with them. The influence of those native merchants was great at the present moment. As had been stated by one of the Zanzibar merchants at an interview narrated that evening in the *Pall Mall Gazette*, "For every foreigner in the country there were a hundred British subjects, and for every acre held by foreigners we hold a thousand." That description gave a very good idea of the position of the colony of merchants at Zanzibar, and our responsibility towards them was very great indeed. We should not adopt a dog-in-the-manger policy of trying to prevent any other nation settling on the East Coast of Africa, but we should not allow unfair encroachments on the rights of our own subjects. The colonising capacities of Indians were very remarkable, or, rather, their facility for settling themselves down for their advantage. It was a singular feature in the native character. Therefore, although he knew personally nothing of Zanzibar, he knew the people who went there tolerably well, because they were the very class found in and about Bombay. An inferior class of Indians were to be found in the colony of Mauritius, and it was wonderful how they adapted themselves to the place. Two-thirds of its population were composed of them; they went as mere coolies, principally from the south of India, and after a period of prosperous work, and a return to their own country for a time, they went back to the Mauritius as settlers; and the natives of Southern India were not generally accounted among the best specimens of our Indian population. The

Portuguese had recently been doing something, and an expedition under Pavia de Andrada had penetrated for some distance into the interior, and had, he thought, discovered some coal very good for lighting purposes, and for mixing with other coal. It was not a very important fact, perhaps, but it showed that the Portuguese had their eyes open, though he could not say, from what he had seen of them on the West Coast, he had been very favourably struck with their administration. We ought also to keep our eyes open. As a very distinguished statesman and diplomatist had said, "what we required in the East was valour and vigilance," and that remark might be applied to all parts of the world where we were. He did not mean that as an incentive to aggression, but rather as a prophylactic. In conclusion, he expressed the hearty thanks of the meeting for the interesting and able paper they had heard.

Mr. HOLMWOOD briefly acknowledged the compliment, and the proceedings terminated.

FOURTEENTH ORDINARY MEETING.

Wednesday, March 11, 1885; FRANCIS GALTON, F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Clare, Octavius Leigh, Hindley-cottage, East Sheen, S.W.
Gilbert, William Henry Sainsbury, 9, Old Jewry-chambers, E.C.
Kirkaldy, John, 40, West India-road, E.
Partington, Charles Frederick, 47, Lower Belgrave-street, S.W.
MacWilliam, George Greenshields, 20, Bartlett's-buildings, Holborn, E.C.
Patterson, George, 85, Carleton-rd., Tufnell-pk., N.
Sharp, James, Carr-hall, Wyke, near Bradford.
Ward, Howard Charles, Yeatton, Lymington, Hants.
Watson, John, Cement Works, Gateshead-on-Tyne.

The following candidates were balloted for and duly elected members of the Society:—

Chadwick, Jesse, 6, Strand-terrace, Derby.
Mumford, Thomas William Bassett, 1, Glendale-villas, Sylvan-road, Wanstead, Essex.
Rawlins, Thomas, 45, King William-street, E.C.
Schlentheim, Ludwig, 40, Holborn-viaduct, E.C.
Smith, Josiah, 51, Park-end-road, Gloucester.

The paper read was—

EXPLORATION: AND THE BEST OUTFIT FOR SUCH WORK.

BY MAJOR-GENERAL THE HON. W. FEILDING.

I think it best to preface this paper with the Latin expression, *Quot homines tot sententiæ*, which may be very freely translated—a tot of men affords a quart measure of opinions. But, seriously speaking, it would be quite absurd for any one individual at any one period of the world's existence to attempt to lay down the law as to how exploration should be carried out.

The most that I can attempt to do is to speak in general terms on the whole subject, using such knowledge as I have gained during my own travels in various quarters of this globe. In order to treat the subject as exhaustively as the limit of time at our disposal will admit, it will be well to divide it under two headings.

1. On exploration generally, and the manner in which the subject should be considered.

2. On the outfits recommended for use by explorers under varying circumstances.

The first heading we must again subdivide into—(*a.*) Scientific explorations. (*b.*) Commercial and geographical. (*c.*) Military. (*d.*) Explorations arising purely out of a love of adventure.

Now, scientific explorations differ or vary exceedingly in their intention and their scope. Their scope depends again upon their intention, and their duration depends upon both these. For instance, botanical explorations may have for their aim a new genus, a new species, or a new variety only of some species. The scope of such exploration may embrace one or more islands in the Pacific Ocean, or the whole of the interior of some unexplored continent such as New Guinea. The duration must depend upon:—(1.) The means of transport to the primary base of operations. (2.) The means of locomotion over the whole or the various portions of the country to be explored. (3.) The physical difficulties to be encountered from man, and from natural obstacles. (4.) The financial means available in this conflict with the difficulties, foreseen and unforeseen, of exploration.

There is much truth in the old saw "money makes the mare to go," and with plenty of money many of the difficulties of exploration are greatly lessened; yet I would here impress on you that plenty of money may be a source of serious trouble, and of much worry to the unexperienced explorer. He is tempted to buy everything he is likely to want, and so encumbers himself with an amount of baggage which he finds it impossible to transport from his base, and from which he finds it most difficult to make a selection.

It would be useless to mention in detail to a general audience the various instruments, appliances, and chemicals, which should be

taken by the explorers in search of botanical, horticultural, geological, mineral, or zoological specimens. Specialists have each their individual special outfit, suitable for the purposes they have in view.

There are, however, certain articles of outfit which are necessary to every explorer of uncivilised, of partially or totally unexplored countries, although their quality and quantity must vary with the nature, scope, and duration of the work to be done.

Most of the researches enumerated above necessitate either slow progress through a country, or a lengthened stay in various selected districts best suited for the operations of the specimen hunters. An explorer, bent on commercial or geographical discoveries, naturally contemplates travel over long distances, and, generally speaking, with less physical and fewer natural obstacles to be overcome in proportion to the distance to be traversed. On the other hand, however, he generally has to travel, and indeed to live, in a continual state of preparation for defence.

The military explorer must again work on different lines. His business is to seek information in countries occupied by a hostile population, with whom, however, his nation is not necessarily at war. He must travel unostentatiously, almost alone, and must avoid all hostile contact with the inhabitants. Such were Colonel Burnaby, when he went to Khiva, and Captain Gill, during his explorations along the Persian frontier, and his subsequent travels in the interior of Northern China. The explorations for purely sporting purposes, or arising from an innate love of adventure, require consideration equally careful, and knowledge seldom acquired otherwise than by personal experience.

For our purpose it will be sufficient for us to divide our inquiries into two different channels. To facilitate and to narrow the question, we will decide that the exploration is to be partly geographical, and so far scientific that the explorer has to report in general terms on the geological and mineral resources of the country to be traversed. There are no roads, but little timber, and that sparsely scattered, except near water, of which the quantity is small, and the quality always questionable and often bad. The rivers in drought do not exist except as chains of muddy ponds, whilst in flood they become impassable for weeks, and overflow their banks often to the extent of from three to fifteen miles on either side. In such a country game would be scarce, and could not be depended upon as the only source of animal food to the explorers. The above data are sufficiently explicit and sufficiently difficult to meet almost every case.

We must now come to consider the manner in which an exploration of such a nature is to be carried out.

1. Would it be possible to establish some one or more subsidiary bases of operations. If the reply be in the affirmative, then comes the questions—(*a*) Where shall they be? (*b*) What shall be stored there? (*c*) How shall these be conveyed thither?

Now the answers to these questions must depend upon the nature of the exploration, *i.e.*, if the intention be to return to the place of starting, or to traverse a continent from sea to sea.

2. What is the nature of the transport to be? If waggons, are they to be light (though strong), many in number, and of different sizes, or are they to be few in number, heavy and solid in construction? How are they to be drawn, by oxen, by horses, or by mules? If wheeled transport be out of the question, what are the pack animals to be, camels, horses, or mules, or some of each of these animals?

Each and every one of these questions has to be carefully considered, because on the solution of one question so many others must depend. It may be well here to enumerate some of the chief circumstances which tend to govern the choice of transport.

1. Nature of the soil generally. If the country to be traversed be very broken in character, covered with thick forests, and known to be traversed by sluggish streams with deep slimy banks and bottoms, it is clear that wheeled transport, unless of a very special character, would not be suitable. Neither would such a country be practicable for camel transport; and yet there can be no doubt but that more stores can be easily carried on wheels, and by camels, than any other way by land. There are, however, very few countries in which exploration with wheeled transport may not be carried out, provided time be no object, and plenty of patience and perseverance be available. This brings us to the consideration of the general outfit of an exploring party.

1. As to stores.
2. As to the mode of transporting them.
3. As to the construction of the waggons, the pack-saddles, harness, &c.
4. As to the mode of packing them and storing them.

1. As to the stores. These must be subdivided under the headings of (*a*), provisions

for the mouth; (*b*), materials for obtaining food, or for offence and defence; (*c*), materials for facilitating the locomotion.

In the choice of provisions, care must be taken to select such articles as are wholesome, nourishing, small in bulk, and not liable to deteriorate by keeping. There must also be variety, so as to promote health, and a proper proportion of such articles of consumption as would diminish the risk of scurvy.

Of meat the best sort is preserved beef in tins. There is very little to choose between that preserved in Australia and that preserved in America, north and south. The tins should not be too large, and they should be rectangular and not cylindrical in shape. Essence of beef (Brand's or Liebig's, in tins or in skins) is a most valuable form of meat. Flour and oatmeal should be packed in block tin boxes, of various sizes, containing from 1 lb. to 4 lbs. each. Sugar should be cane sugar, powdered, and packed in ½ lb. rectangular canisters. Tea—the best for the purpose is Goundry's compressed tea; it is manufactured in tablets of ¼ lb. in weight, and subdivided like chocolate tablets, into eight portions, one of which is ample for tea for three or four people. Being wrapped in lead paper, it stands any climate, and I have known it to keep good for five years. Salt should be kept in stone or thick glass jars, with screw or cork-lined stoppers. Lard should always be taken, and should be kept in stone jars, capable of being rendered air-tight. There is an excellent form of compressed and dried vegetable tablet manufactured in France; and there is also a preparation of dried potato, in powder. No expedition should be without these to keep off scurvy, that terrible scourge and bugbear of all explorers. Ginger, peppers, red and black, should be carried in thick glass pickle bottles, with air-tight glass stoppers, edged with cork. Brandy for medicinal purposes should be carried in small wooden kegs, covered with thick felt, and with a locked covering to their bungs. A provision of lime juice should be similarly carried in kegs of different sizes. There should be several spare kegs of the same description, kept constantly filled with fresh water. In addition to this provision of water, each animal should have a canvas water-bag slung by a strap round his neck. These bags keep the water cool, and each should have the neck of an old soda water bottle sewn into the orifice used for filling it; the vessel can thus be easily used, without detaching it from the animal carrying it. Water-bags on the same principle, only much larger, are made of well-seasoned leather, and are slung by straps and iron rings on to a pack-saddle. At first the water has a nasty flavour; but the bags soon cease to affect the taste of the water, and are indispensable on long waterless marches in a hot climate.

Whilst on the subject of water, it may, perhaps, not be out of place to impress upon you the necessity in observing the greatest care in the selection, and, generally speaking, the after treatment of water. As a general rule, the only water which can be drunk with safety, without fear of evil consequences, is that which springs directly out of the ground, from rocks, or which is obtained from a permanent running stream, the bed of which is not muddy, and on the banks of which there is not an exuberant vegetation. Even in the case of water issuing from rocks, care must be taken to avoid water issuing from copper or lead-bearing rocks. In these cases a small quantity of sulphuric acid would at once detect the presence of the mineral in dangerous quantities, as the water would become discoloured.

In most countries subject to drought, the water requires special treatment; mechanical filtration is seldom practicable, or even safe. I have come across it as thick as pea soup, and sometimes covered with a growth of green or red weeds. In such cases, the first operation is that of skimming with a skimmer made out of a forked stick, with a pocket handkerchief or other piece of linen stretched tightly between the forks. This done, scatter a pinch of powdered alum into the vessel in which you have collected the skimmed water; this will cause a great deal of the matter in suspension to precipitate. Then pour the water slowly into a filter filled with the charcoal of your last night's camp fire, mixed with any sand or fine gravel which may be obtainable, and which you have previously washed. It must then be boiled, and skimmed whilst simmering, and only when no more scum arises on the water is it really fit or safe to use. It is a good plan always to fill the kettle—or, still better, the cooking pot—with water the last thing at night, and put it at the edge of the camp fire to simmer (not to boil), and always to fill up the water kegs and bottles from what is left over from each morning's cooking. It is also a good rule never to drink plain cold water in the tropics. Each man should carry in his pocket half a handful of oatmeal, and put a pinch into his pannikin of water when he fills it for drinking.

I once travelled 1,400 miles across a portion of the centre of Australia, and began my journey after a drought which had then lasted eighteen months, and which only broke up the day I reached the sea coast. It was only by the strict enforcement of these precautions that (under Providence) I never had a case of illness from fever or from dysentery. Personally, I always carried in my pocket a few "thirst lozenges," which are, I believe, nothing except a compressed form of Lamplough's pyretic saline.

Before closing the enumeration of the *provisions de bouche*, it is well to add a list of the medicines and surgical instruments necessary to every expedition:—Rhubarb, essence of ginger; about 100 pills of colocynth and henbane; about double the quantity of quinine pills, made up in small doses of three grains each; some opium pills; a couple of bottles of Dover's powders; four bottles of sweet spirits of nitre; about 100 pills of podophyllin in small doses; camphor, and chlorodyne. Two lancets, two abscess knives, two catheters, two enemas; some surgical needles, and some silver wire thread for sewing wounds; a silver probe, and two vein or artery forceps; a syringe with various nozzles for various uses. Sticking-plaster of various sorts, and some prepared lint and medicated wool; and some vaseline, carbolic acid, and carbolic soap. All the medicines should be in glass-stoppered bottles, the stoppers having been lubricated with pure glycerine previous to insertion. The medicines, &c., should be divided into at least three portions, so that each waggon or each detached party should have a complete set of everything. There is no greater mistake than to have everything in one medicine chest. All boxes should be avoided, as in a very damp or a very dry climate boxes are apt to come to pieces with the rough handling that every package gets at the hands of those who often have to do the packing and unpacking of animals two or three times each day.

Clothing.—Take as little as possible when starting from England, as you can get most articles necessary for explorers at the place from which the waggons would make their start. Of personal attire, the following are those which I consider sufficient for most expeditions:—Four shirts made of grey flannel, with two buttons on each wristband, to admit of them being worn loose or tight. Four long merino drawers, double seated and double down the inside of the thighs. Four pair of thick knitted woollen long stockings. Two cholera belts, one of knitted worsted, the other of flannel about a quarter of a yard wide and three yards in length, to be wound round the body or fastened with a safety brooch. Six silk pocket-handkerchiefs (white), and of the thickest and best quality. They are useful sometimes when travelling in the very early morning, to serve as a curtain against the sun's rays, which often at that hour strikes with great force on the nape or side of the neck under the hat. A Norfolk jacket of good woollen serge or light tweed, made double breasted, so as to be worn either open with the lappels buttoned back, or buttoned across double over the chest and stomach. It should be made like a garment known by miners as a jumper, not cut in at the waist, but merely kept in at the waist by a belt. This belt should be made of two pieces of soft leather, about $2\frac{1}{2}$ inches wide, and stitched together at the edges so as to admit of dollars or other coins being kept in the belt and slipped in at either end, and prevented from falling out by a flap and button at each end.

If a sword has to be carried, it is best carried fastened on to the side of the cantle of the saddle by a round strap and button of leather. If a revolver has to be worn, it is best carried in a frog supported by a webbing belt over the right shoulder, which should be kept in its place by the waistbelt.

The best hats are of grey felt, of a helmet shape, with means for ventilation round the edge and at the top. They should be provided with a chin strap, to be worn when riding fast or against a strong wind. The best boots are those known as the Paliser boot. They reach nearly to the knee, and are laced up for about six inches from below the instep, so that the boot can be always easily got on and off, whilst remaining watertight. I prefer those made of porpoise hide to any other, as they are lighter and more supple in wear.

Dogskin driving gloves should always be taken, as their use prevents sun boils, blisters, and many sores arising from thorns, &c., on a journey. Breeches should be made very loose, except just below the knee, where they should be fastened with a buckle and strap, or tied with thongs of porpoise hide. A hunting whip with a hammer handle and a long brown leather lash is always useful, and is a necessity where there are many spare horses to be driven along with the party.

Camp Necessaries.—India-rubber buckets, two to each waggon, should always be carried, to be used for watering the horses whilst in harness. Palkee hammocks, made of water-

proofed canvas, are the best and most portable form of bedstead, and it is always unadvisable to sleep on the level of the ground. The blankets should be loosely sewn together round three sides so as form bags. This plan saves many a sleepless night. Moreover, it keeps snakes from getting in between the blankets. A waterproof sheet, with eyes round the edges, is most useful, as when thrown over the ridge pole of the hammock it can be lashed to the sides of the hammock, and serve as a complete shelter even in the heaviest storms of rain and wind. A light folding chair, or if this be too large, a beach seat with a back, is a great luxury, and is almost a necessity in wet ground.

We have now to consider the selection of such materials as are necessary to secure supplies of fresh provisions to protect life. First and foremost are guns. These should be breech-loaders of the simplest possible construction, and of 12 bore. Each gun should be provided with 20 steel cartridges. These are really indestructible, and are very easily reloaded and recapped; and having a female screw turned for a distance of an inch inside the cartridge, there is no difficulty in making the wads to keep in position.

For ammunition, shot of all sizes should be taken, the larger slugs for use against man or large animals. Powder should be carried in two small copper magazines, each containing about 7 lbs. of powder in half-pound canisters, fitting into the outer cylindrical copper case. These canisters should have screw tops with leather washers to them. The canisters should always be kept full so long as there is any powder in them. When a canister cannot be filled with powder, it should be filled up with cotton wool, rags, or even crumpled up soft paper. It must be remembered that any expedition is liable to be reduced to pack animals only, and then the attrition is so great that everything which can rub, soon gets rubbed to the finest dust.

When it is known that there are rivers or lakes, it is well worth while to take a casting net, and even a small seine net of strong tanned twine. A large provision of hooks and fishing lines of all sizes should always be taken, as they are not only useful in the obtaining of a change of diet, but are very valuable as an article of barter with natives.

For personal defence the best weapon is the largest sized Colt's revolver, with a stock which can be used at the shoulder, and is detachable. When on horseback it is best carried in a bucket, like our cavalry carry their carbines. A good one shoots with wonderful accuracy up to 100 yards. A hunting knife, of a pattern of my own, I have found the best, as it is light, and yet strong enough to cut away a fairly large branch. The sheath is of bamboo, and there is room in it for a knife and fork of steel, flat, with wooden handles screwed on each side of the shaft. The blade of the hunting knife is made light by having two deep grooves cut out of the thickness near the centre of the blade, so that, whilst the blade is made lighter, it is also thereby rendered much stiffer.

The only other stores which we have to review are those required in reference to locomotion—*i.e.*, spare harness, leather, rivets, and copper wire for repairs, spare nuts, screws, iron clips, splinter bar caps; tools, such as augurs, centre bits and braces, saws, files, chisels, screw wrenches, screw drivers, gimlets, awls, sewing needles, wax and strong thread, felt for saddle cloths, roll of flannel for saddle linings, raw green hide, and skins of dried leather, half-inch iron rods, flat iron hooping for strengthening splicings, adzes, jack planes, spoke shaves, sharpening hones, files, punches, rasps, horse shoes, nails, and shoeing tools, felling and trimming axes, cross-cut saws, hand saws of three or four different sizes, from 3 ft. 6 in., to 15 in., clamps, light and heavy hammers, a few pairs of blacksmith's pincers and tongs, a couple of good bellows (hand), an assortment of nails, screws, copper and steel, D's, buckles of different sizes, and straps of various lengths and widths.

Having enumerated the stores necessary to an expedition, the next thing to be settled is the means of their transport.

It is rare that the only transport available is man, but yet in some tropical countries, covered with thick jungle, and where the ground is too rocky and broken even for mules, donkeys, or cattle, it is necessary to use men, and men only, for this purpose. Chinese and Japanese coolies will carry great weights balanced on two ends of a long bamboo cane, which rests on the shoulders. Sometimes two men will carry a heavy package for weeks at a stretch, slung on a bamboo cane between them. In Africa and South America, the natives prefer to carry heavy things on the top of the head. When packages are carried slung, the slings should be made of plaited ropes of green hide, kept well greased. Everything else wears out almost immediately. Every expeditionary force should be provided with pack-saddles, and with the means of constructing

them. Personally, I prefer the sort in use by the Basque population in the Pyrenees. It has the advantage of simplicity and cheapness of construction, and of being easy to use and to repair. The best form of camel pack-saddle is the one used by the Arabs, who contract with pilgrims to and from Mecca. Numnahs of felt should always be used, both with saddles and pack-saddles. If carefully adjusted, they admit of animals being kept in work with sore backs, should it be necessary.

The best form of bridle for all animals are those made entirely of tanned twine webbing. It is quite impossible to break them, and they are comfortable both to the heads of the animals and to the hands of the rider or driver. Besides this, they do not become slippery in wet weather, neither do they require any care to keep them in working order, as leather does in hot or dry climates.

Hitherto, we have treated entirely of man or of animal transport; but there are very many countries where it is not only possible, but very advisable, to adopt wheeled transport.

The class of wheeled transport must depend upon three conditions:—1. The nature of the country to be traversed (I put roads as out of the question). 2. The quantity of stores to be carried. 3. The quantity and quality of the animals available for its traction.

It is now almost an exploded idea that a waggon must of necessity be a heavy, cumbersome vehicle, with thickness and weight as the governing virtues of all its component parts. The Boers and others in South Africa still adhere to the old pattern, from habit and ignorance more than for any known reason. In America and in Australia, where the country is just as difficult to traverse, very much lighter vehicles are used with great success.

It is well to have several sizes and types of vehicles in every expeditionary outfit. Two-wheeled carts, long and broad, with draught from the shafts and outriggers at the sides of the shaft, which would admit of its being drawn, if necessary, by three horses abreast; four-wheeled waggons, light and medium, with pole draught, with side springs, and india-rubber buffers on the axles, these latter being connected by a perch. All waggons and carts should have lever brakes, capable of being worked by hand and foot by the driver. There should also be iron skids, or shoes and chains to be used if required, in addition to, or to replace the brake. The chief things to be borne in mind in the construction of vehicles for expeditionary transport are—

1. Great simplicity of construction.
2. As few parts as possible.
3. Screw clips should be used in preference to bolts and nuts, inasmuch as every bolt weakens the wood traversed by it, in proportion to the diameter of the bolt.
4. All parts should be made of such shapes that they can be readily copied and replaced by an unskilled workman.
5. The wood should be perfectly seasoned, neither so dry as to diminish its toughness, nor too full of natural moisture or sap, and no iron should be used except where absolutely incapable of being broken, or where the use of wood would be incompatible with strength and endurance. It may, however, be used where, in the event of its breaking, it could be easily replaced by wood.
6. The height of the axles from the ground should be the same, and not less than two feet. It is seldom that a waggon has to be turned at a very acute angle, therefore no great amount of "lock" is necessary. When making a track through a forest, much time and labour are saved by cutting the trees off at about two feet from the ground, as they are not nearly so large in girth at that height, and it is less fatiguing to the men felling them with cross-cut saws or axes.
7. The various parts of each waggon, excepting the bodies, should be interchangeable, so that in the event of a complete breakdown, the unbroken portions of the disabled waggon could be utilised in the repairs of others. This is very essential, as tending greatly to the reduction in the quantity of spare stores.

We may, therefore, proceed to consider the construction of a waggon under the following heads:—

1. The under carriage, including the wheels.
2. The mode of traction.
3. The body (including the tilt where necessary).
4. The means for suspension of the body.

As stated under paragraphs 6 and 7 above, the parts should be interchangeable, and the axles should not be less than 2 ft. from the ground. It follows, therefore, that the wheels should be of the same diameter, and not less than 4 ft. 2 in.

One of the great troubles in all explorations, especially in very hot and dry climates, is the difficulty experienced in keeping the wheels in working order. The spokes shrink, and unless this is immediately found out and remedied,

by caulking the gaps left in the wheel stock and felloes with white lead and cotton waste, or with oakum, wet gets in, and the end of the spoke soon rots away. The slightest sign of looseness anywhere in the wheel must be at once attended to and remedied; green hide (cut in strips half an inch wide) wound in and out the spokes near the stock, greatly strengthens a wheel of which the parts have begun to shrink. In some very dry climates, no wheel of ordinary construction will stand. On one of my expeditions I had each night to take off all the wheels and lay them in water till daylight, in order to keep them together, and even with this precaution, the wheels eventually turned inside out and fell to pieces. There is, however, a form of wheel which seems to me to be likely to last longer than the sort in ordinary use. It is that known as the Madras pattern, and the invention is claimed by an American named Sarven. The spokes fit round an iron stock, and are kept in position by two circular plates, bolted from outside to inside the wheel. This would admit of a broken or damaged spoke being easily replaced, or they could be wedged up from the centre by the insertion of thin bits of iron, tin, or some hard substance, between the inner end of the spoke and the stock. Another difficulty arises from the difficulty of keeping the tires on. In England it is easy enough to remedy the tendency which all tires have to lengthen. They can be cut, shortened, and re-shrunk on the wheel. In exploring work, the tires, as a rule, do not permanently increase in circumference, as they do from use on hard roads here, but the wheels shrink away from them with the heat, and this same heat expands the iron tire, and so causes it to lose its contact with the felloes.

The evil results arising from these causes may be minimised in two ways:—

1. By constructing the tires slightly convex on the inner circumference, and by making a corresponding concavity in the outer circumference of the felloes.

2. Sometimes, however, the shrinkage is so great, that it becomes necessary to cut and shorten the tire. As it is almost impossible to secure a good weld to reclose it, it has to have the two ends filed to a feather edge, brought together, and then firmly clipped to the felloe at either end of the splice. The tire may be wedged tight, and secured with clips.

The axle-trees should be of the best toughened iron, bedded in tough timber, and clipped In length they should be 3 ft. 8 in. to 3 ft. 10 in.

The greater the breadth (in moderation) the greater the stability of the vehicle when moving across an incline. Moreover, with all the wheels of equal diameter, the lock is increased by leaving a greater space between the waggon body and the front wheels. The axle-trees of the fore wheels and hind wheels should be connected by a straight perch made of tough wood, such as hickory. Inasmuch as there is very little "lock" required, there is no necessity for any complicated or delicate wheel-plate (or fifth wheel). A stout transom, with an iron eye through which the king bolt would pass, and the axle-bed connected with the splinter bar by two wheelirons, and braced at the rear by a stout sway bar, is all that would be required. These should be all straight pieces as far as practicable, and clipped together (not bolted). In very broken and precipitous ground the pole might be taken out, and the movement controlled by ropes held by men.

As regards traction, it would be a great gain if the pole could be dispensed with, inasmuch as in very rough ground it knocks the wheelers about sadly, and it is more frequently broken when working in difficult ground with untrained horses and bad drivers than any other part of a waggon. It is, however, sometimes necessary, and must therefore be provided for. It should be attached firmly to the splinter bar, and the bar allowed to move freely. The attachment should be by means of two iron bars passing through eyes clamped on to the splinter bar at the two ends, ending in two iron stays coming out from the bars at an angle of about 20 degrees, and clamped on to the pole. The pole is thus worked freely up and down, and the pressure would be taken off the jaws of the futchells by the two jointed iron bar stays.

The hanging pole, moreover, necessitates a contrivance to relieve the horses from having constantly to support its weight. This can be done by having a strong hook, fastened by a clamp, at about one-sixth of the length of the pole, from the splinter bar. On to this hook is fastened a chain, or strap of plaited raw hide, which, running through a sheave (firmly fastened by a broad plate bolted on to the footboard), is hooked at its other end on to a hook fastened to the under side of the front of the body of the waggon. These hooks must be strong, and have a broad bearing where fastened to the carriage body. It would even be

advisable to introduce a spiral spring at one end of the chain, to take off the sudden strain occasioned during the passage over very rough ground.

When driving four or more half-trained horses on broken ground, it is safer to use no pole piece and bars, but to use long traces made of green hide rope, kept up by loops hanging from the wheeler's trace carriers, the leader's traces being kept apart by means of very light hickory bars, kept from slipping by green hide thongs passing through the ends of the bars, and fastened through loops in the leader's traces. It is well, however, to be able to use the pole and bar draught; with that view, the pole piece should be fastened by clamps, counter sunk round the pole head. The hook should be made on a twist, to avoid the necessity of using a strap, as with wild horses it is necessary to be able to detach the leaders with as little delay as possible.

Germane to the subject of traction is the question of how to bring it into control. The ordinary skid or shoe cannot be depended upon in rough, rocky ground, as the wheel is apt to jump out of the shoe. The ordinary hand brake, acting on the front of the hind wheels, is insufficient. To these two should be added a friction brake working on the hinder circumference of the hind wheels by means of a bar, shod at the two ends, which can be compressed against the wheels by a screw working on the end of the perch, prolonged for this purpose.

If the tires should be secured by clips at any part of the journey, the projections would interfere with the brake blocks, so the brake blocks should then be applied with enough pressure to prevent the wheels revolving.

Suspension.—If very rough country has to be traversed, it is well to have the body of the waggon suspended on springs, so as to save the damage done to the stores, as well as to the waggon by the jolting.

The best form of spring appears to me to be that adopted by some of the best carriage makers in the construction of gentlemen's omnibuses for station work with heavy loads.

The springs are single, and coupled to the scroll iron on the body by a shackle, inside which is an iron coupling or robin. These are practically unbreakable, as the coupling takes off the strain from any sudden and heavy jolt. There should be, however, india-rubber buffers fastened on to the body to minimise the shock, if it were to be so severely jolted as to come down suddenly on the bed of the spring.

I have found it very useful to have a strong swinging tray (made of strong ash planks one inch thick) fastened so as to hang between the axle-trees. The planks should not be too close together to prevent axes, spades, picks, and such like heavy articles being attached to the planks by means of thongs tied round the planks, and passed through holes in the handles of the implements. The whole tray should be constructed that it can be readily taken to pieces, and the planks utilised in the passage of boggy ground, or in the sandy beds of rivers, or in running the waggons up very steep inclines in soft ground. I have found them of great use, especially in deep ground, where they can be put under the wheels. Another advantage arising out of the use of this tray is, that as in it are placed heavy articles, the centre of gravity is brought lower than if the same weights were carried in the waggon itself. There should also be a small water barrel, covered with felt, hanging under the waggon at the rear.

Covering.—Every explorer's waggon should have a tilt, to serve as a shelter from sun and rain. It should be made of waterproofed canvas, and have a fall-down piece in front to shelter the driver, and a curtain behind, with thongs to enable it to be kept closed when needed. The framework is best made of hickory, fitting into rectangular sockets well outside the framework of the body, so as to allow of ventilation from under the sides, and to give greater head-room space in the interior. There should also be a ridge pole of hickory running through rings clamped on to each rib. This ridge pole can be utilised for slinging a hammock in case of sickness or wounds during the march.

Fittings.—Under the driver's seat should be a moveable box, in which to place all the tools and materials necessary for mending the harness, or any part of the waggon. The box should be constructed in trays, so that each thing may have its place, and be readily available. Each waggon should have its camp kettle, which should be slung on hooks under the rear of the body. On the splash-board there should be hung a stout leather bag, in which might be kept strong twine, a sharp knife in a sheath, and a hatchet and hand-axe for ready use. Each waggon should have a strong lantern for use, with good wax candles.

Harness.—The great desideratum is to have as little harness as possible, and that it be strong without being heavy. Headstalls and

bridles may be made of stout webbing dipped in tan. The reins should be round, and of plaited green hide. There should be as few buckles as possible, and the ends in the driver's hands should never be buckled, but merely kept together by a loosely made reef knot, which can easily be undone in the event of its being necessary to let the leaders go clear. The traces should either be made of plaited raw (or green) hide, or of the best two-inch rope.

It is well to be provided with both collar and breast draught, so as to be able to change from one to the other form of draught in case of need. Copper rivets and copper wire are most useful for mending harness and saddlery, and plenty of it should be with the stores. There should also be plenty of hobbles to prevent horses from straying too far from camp at night in search of feed. Some horses, however, become so clever in hobbles that they can even gallop in them. In such places the best plan is to attach a cord from the head collar to the hobble of one leg. It is well to have a few cattle bells to attach to the necks of some of the horses most likely to stray. By these means much annoyance and delay in starting are to a great extent avoided.

Horseshoes.—Although in most expeditions the horses are not shod, it is wise to take a small supply of shoes and nails, to be used in the event of it being necessary to cross a tract of stony or rocky country, where horses would soon wear down their feet, and become tender-footed and useless. The class of shoe must depend upon the breed and class of horses used. The Arabs, who ride their horses over very rocky and stony ground, most frequently shoe their horses with plate shoes, covering the whole of the sole; but this form is not suitable to a wet soil or a stiff clayey country. Every party should have a blacksmith amongst its members, and it is well that most of the party should be able to shoe a horse without driving the nails into the quick.

Packing the Waggons or Pack Animals.—There are certain principles in packing, whether it be waggons or pack animals, which should never be lost sight of.

1. To make each waggon or group of pack animals complete in itself, *i.e.*, it should contain everything necessary to the existence of those in charge.

2. So to arrange the stores that those most frequently used should be so packed that nothing else need be disarranged in order to get them out.

3. To arrange the stores in such a manner that the heavy packages should be equally distributed over the surface of the waggon, or amongst the beasts of burden, and that the lighter articles should always be so well secured as to prevent the possibility of their becoming loose, and thus spoiling their contents.

I have known hard biscuits reduced to powder by the omission to pack the case with paper, so as to keep the box always full; clothes worn into holes by attrition from their having been placed in contact with hard corners; maps, and even books, destroyed in the same manner.

Now, as regards the packing of animals, it is quite impossible to do more than lay down first principles, viz.:—

1. That the panels of the pack saddle must be well and evenly padded; this should be looked to at every halt and promptly remedied, otherwise sore backs will ensue.

2. That the weights should be quite evenly divided on either side of the saddle, so as to avoid the necessity of having to draw the girths too tightly, or of having to stop frequently to re-arrange and trim the burdens.

3. The weights should be kept low, so as to lower the centre of gravity as much as possible. This is especially necessary when any mountainous country has to be traversed.

4. The packages ought not to stick out too much laterally, especially when wooded country or a narrow rocky pass has to be traversed.

5. Where practicable, it is best to put some soft or yielding package outside the others, as the pack animals often run against one another, and damage in such cases might arise both to the animals and to the packages, if the latter were hard and unyielding. Moreover such a plan enables the surcingles to be better arranged.

6. Never attempt to pack an animal alone. The weights having been arranged on the ground, the animal should be led between them, and the packages should be placed on the hooks simultaneously.

7. The same precautions should invariably be taken when unpacking, as at that time it is so very easy to "wring" and to "rick" an animal's back.

8. At every halt of more than an hour the packs and pack saddle should be removed, and, where practicable, the backs should be washed with salt and water, alum and water, or carbolic soap and water, then rubbed dry; and just before repacking, the back should be

brushed with a penetrating brush, to remove all grit, sand, or dander, as almost all horses, mules, and asses, roll on the ground as soon as their saddles have been removed.

9. After each day's march, the back of every animal should be examined, and the slightest tenderness or shrinking observed. The smallest sore or abrasion should be carefully washed with carbolic soap, and dressed with vaseline ointment. If there be no spare pack horses, and rest be an impossibility, then a numnah of thick felt should be interpolated between the back and the saddle, and a hollow, or even a hole, cut in the numnah, to prevent any pressure coming over the sore place.

The same treatment should be observed with respect to the shoulders and withers of the harness animals, remembering the old proverb, "a stitch in time saves nine."

There should be an intelligent, capable man in charge of all the wheeled transport, another in charge of the pack animals, and a man in charge of the spare and sick horses. Each driver should be responsible for his waggon and team, and there should always be a mounted man with the waggons, and with each detached waggon. There should be a cook in whose charge all the stores should be, and he should ride, if possible, so as to go forward with the advanced party, to light the fires, collect the wood, and, where necessary, improve the water supply. He should carry a hatchet and a small spade.

The man charged with the supervision of the sick and spare horses should have another man with him, as it is often necessary, especially at the commencement of a journey, to leave a man behind to search for and bring up horses which have strayed, and sometimes even gone back from the camping ground.

In every exploration where wheeled transport is employed, there should always be a reserve of a class of horses called "emergency" horses, *i.e.*, horses able and willing to give a steady and strong pull. They should be well bred strong horses, and should not be used except when required in heavy ground.

In countries where the water supply is uncertain, it is the best plan to send two men ahead with a spare horse, to explore for water. When found, one of the men returns on the spare horse.

As a rule, from ten to fifteen miles may be considered an average march in a new country, in which there are no physical difficulties. I have, however, more than once, only been able to progress two miles in the day; whilst in order to reach water I once had to make, in three successive days, marches of forty-one, forty, and forty-three miles. These were, however, made with pack animals, and without waggons. Before concluding this paper, it may be interesting to most of you to hear a few remarks on the manner in which exploration for water is generally conducted. Experience, and even common sense, tells us that in a hot or a dry climate, animals and birds are but very seldom found far from water towards sunset, and that at sunrise they generally leave the vicinity of water on their search after food. Observations as to the direction of the flight of birds, and especially of all the parrot tribe and the carrion birds, will generally lead to the discovery of water.

In almost every country there are some descriptions of shrubs and trees which will not grow except in the vicinity of water; and even where this water may not be obtainable on the surface, it can, under such conditions, be found by sinking in suitable spots in the beds of the streams where those shrubs or trees are found. I once travelled for three days down the bed of a river which was quite dry, and yet by sinking from six to ten feet in the bed, a sufficient supply was obtained. It seems to be a provision of nature that in very hot and dry countries the streams almost invariably run for considerable distances under ground. With a very rudimentary knowledge of geology, and by the observance of the natural signs of water peculiar to each country, travellers may, and do, often find water where an unobservant man might die of thirst. This all-important question is of more interest than usual at the present time, when an expeditionary force, composed of European troops, is about to undertake the opening up of the trade route from Suakim to Berber, on which the two last stages, fifty-three and fifty-two miles respectively, are without any visible supply of water. Personally, I have but little doubt, from the geological formation of the country, and from the conditions of the water supply along the rest of the route, that these two dry stages will be bridged over by the discovery of a subterranean supply of good water. Let us hope that capable men may be employed in the exploration of that part of the route, and that our expeditionary forces on the Nile and the Red Sea may be able to join hands at Berber, and thence proceed to re-establish the prestige of British arms in the Sûdan.

DISCUSSION.

The CHAIRMAN said that the most experienced traveller would have derived instruction from this paper, and from the exhibition of articles with which it had been accompanied; and he had no doubt many gentlemen would desire to ask General Feilding privately who was the bootmaker who had supplied him with the pair of boots which had lasted him twenty-three years. As had been very truly remarked, it was very difficult to speak generally of a traveller's outfit, the requirements were so varied; so dependent upon the physical features of the country, upon the character of the inhabitants, on the climate, upon the supplies to be met with or to be bought, either *en route* or at the point of departure, that it was impossible to lay down any general rule; and he thought General Feilding had done well to limit himself to the consideration of the outfit necessary for travelling in that part of Australia where he had made so adventurous a journey. Still it struck him that the title of the paper was somewhat wider than the subject covered; and in considering the more important travels of recent years, he thought very few of those who had made them would have been able to avail themselves of the hints contained in the paper. For instance, Mr. Im Thurn had just returned from Roraima, in British Guiana, where he had travelled entirely on foot, and the expedition just going out under Mr. Forbes to New Guinea, though it would be partly in boats, would be otherwise entirely on foot. Looking at the explorations on the basin of the Nile, of the Congo, on the eastern side of Africa, and in Turkestan, he thought that generally the conditions would not admit of taking many of the articles which had been mentioned. But though the paper did not profess to cover everything, it covered one part very thoroughly, and one of the most important questions it raised was as to the most suitable kind of waggon, if not for explorers, for persons who had to make long journeys in wild countries; and on that point he hoped there would be some useful discussion. He should also be glad if any one present could afford information on the subject of boats, especially the Nile boats, which had done such excellent service—on what patterns they were built, on what experience they were designed, and whether the work they had gone through had suggested any modifications. The paper would, perhaps, have been still more valuable if it had given an account of the weights of all the articles recommended to be taken. It was very useful for a traveller, as soon as he was well on his journey, to make a catalogue of all he had with him, and to weigh every article, and when he returned home to repeat the process. He would generally find that a great deal he had taken had proved useless, and had been abandoned, and that another large part might have been replaced by much simpler contrivances, and he would also probably find some few things which he had omitted. If General Feilding could give any information as to the weight of his outfit, which seemed to him rather more extensive than travellers usually took, he thought it would be valuable.

Mr. G. N. HOOPER said he would confine himself to the question of vehicles, with which he was more particularly familiar. It seemed to him that the great difficulty of all explorers travelling on wheels, was to keep the wheels together to the end of the journey, so much so that, in some cases, the waggons had had to be abandoned 300 miles from the journey's end, and he could easily understand that this might mean not only a great deal of inconvenience, but possibly loss of life, or the failure of the expedition. The Government had investigated this subject, and had overcome the principal weakness, viz., in the stock, which was the weak point in all hot climates, for directly the spokes began to spring, the trouble began; and unless they could be rapidly and effectively fastened, the vehicle must come to a standstill. The difficulty, with regard to the centre, had been overcome by the Government pattern; the Americans had a somewhat similar plan, but the English was the better, because, by taking off the front plate, you could immediately put in a new spoke in case of breakage. Then the next difficulty was how the felloe was to be replaced in case of need. His suggestion was that a few spare felloes should be taken, because any wood which could be obtained on the spot would be unseasoned; and he had put on the table a specimen of a felloe such as he recommended, split in half after being made, which could be thus inserted without removing the tire, and then firmly fixed together by bolts. The greatest difficulty of all, however, was in the tightening of the tire, and he had proposed a plan which might be useful, though he should not recommend it for highly finished carriages to be used in Hyde-park or Regent-street or in any part of England; this was to have iron wedges, which might be driven in between the tire and felloe in any required number until the tire was quite tight, and they were provided with a corner flap, so that, when in place, screws could be inserted to prevent their dropping out. By using only the best materials and workmanship, and taking a few spare parts, he thought all difficulties with regard to the wheels might be met. Too much stress could not be laid on the principle of making all the parts interchangeable, as was done in military waggons and gun-carriages. An institute with which he was connected had been recently in communication with Sir Joseph Whitworth, the greatest authority on this subject, and he hoped the result of investigations now being made, both in London and Birmingham, would be of great advantage in the construction of vehicles of all kinds. It was not, perhaps, generally known that wheels of first-class quality were the exception rather than the rule, and that no matter how excellent the material, the highest skill and most conscientious workmanship was necessary in order to ensure a good result as

regards durability. He would also insist on the point that, given good material and workmanship, there was no need to make wheels very heavy on account of the roughness of the ground. In a matter of this kind the expense of construction should be a secondary consideration. With regard to axles, it was a question whether common axles, or the Mail or Collinge pattern, should be used. Common axletrees were extremely simple in construction and not liable to accident, but, on the other hand, they required lubricating every morning, which must be a disadvantage when every hour was of importance. If a Mail or Collinge axle were not too delicate in its mechanism, it would save time, as once in two months would be often enough to lubricate it. He was not prepared to agree with General Feilding's suggestion that tires should be made convex and the felloes concave, because the tyre being put on red hot, there would be a danger of burning the edges of the felloes next to the sunk surface, and thus all the advantage would be lost.

Mr. J. Matthew remarked that the means of transport must vary with the character of the country, and, as a matter of fact, the countries in which you could travel on wheels at all were very limited in extent. In the Soudan and in great parts of Syria all transport had to be effected by means of beasts of burden.

The Rev. E. L. Berthon said there was nothing very remarkable in the whale boats used on the Nile, either in form or material, except that the material used was so scanty that the Canadian boatmen complained bitterly of their frailty, and the frequent accidents which had occurred, were in consequence of the far too small scantling. But the builders were confined to certain limits, the boats being specified to weigh not more than half a ton, and to be 30 ft. long, which involved a crux which no boat-builder could get over. The wonder was not so much at the goodness of the boats as at the excellence of the soldiers and others who managed them. He had had the honour of building a good many boats for the Government for this purpose, but had not yet heard a word about them; they were the same size as the other boats; but were similar to some exhibited that evening, except that they were in three sections instead of two, and when collapsed were only about 10 in. wide. Each part weighed about 2½ cwt., so that they could be easily taken out of the water when rapids were reached, carried to any required distance, and launched again. Seven years ago, the great man whom they were all lamenting, his friend General Gordon, had several of these boats in the Soudan, and found them very useful, and 250 of them made in two sections had been supplied for the French service. They were admirable for topical climates, as no heat affected them. They were essentially life-boats, for if one of the outer skins were injured, you only got water into one compartment, and they would stand concussion against rocks much better than wooden boats. When made in two compartments, they could be set up on end, as shown downstairs, and the sail or sheet thrown over made an admirable tent, which could be erected in a few seconds.

Mr. H. Liggins said he had been, for forty years, sending carts made in England out to the West Indies for carrying heavy loads connected with the sugar industry, and he could state most positively that there was not a cart-builder in England who could make one fit for the purpose. Even Mr. Hooper could not make wheels which would stand the wear and tear of the West Indies and the heat of the sun, for the simple reason that they would be made of English wood, which was not suitable for that climate. He had had experience of the best agricultural implement makers in England, but the result was far inferior to those produced by negroes who had no notion of finished work, but who used native wood, bullet wood and other kinds, which practically would last till doomsday. English wheels would not stand in South America, where the climate was very variable; the nights were very damp, and English wood would absorb moisture far too readily. As a rule, every traveller should provide himself with his outfit in the country he was in. He had a friend who had just crossed the Cordilleras from Valparaiso to Rio Janeiro, but he travelled in native carts and waggons. General Feilding did not recommend leather traces but ropes, which was only carrying out the same principle. Everything which could be obtained in the country should be employed. He was surprised the reader of the paper had not mentioned several things connected with the outfit, such as a compass, sextant, drawing materials, and scientific instruments. With regard to the boats on the Nile, he could not agree with Mr. Berthon; they were very good boats, like ordinary steamboat gigs, made for easy lowering in a gale of wind, safe in the water, easy to row, and capable of carrying a great weight, and he thought they had proved more successful than could have been anticipated; if they had been made stronger, they would have been very heavy to row. The only mistake, in his opinion, was in not having them built on the spot by native boatbuilders, and from native timber. Boats made to take to pieces, and to collapse, were, in his opinion, only fit for use on ornamental water like the Serpentine. Although he knew many ships were supplied with Berthon boats, he had never seen one used, and such an one would be the last he should choose if his life depended on it; he would rather choose the smallest dinghy made of wood.

Mr. Hampton said he had had some experience, during the last three years, of wheeled vehicles, within five or six degrees of the line, in carrying up heavy machinery for the gold mines, and he found that none would stand like those made of the native bullet wood.

General Baillie said he too had been rather dis-

appointed at not hearing more about the scientific instruments which should be taken by an exploring party. With regard to wheels, the Madras wheel seemed to have been recently claimed as a new invention, but he recollected it well when he went to India in 1842, and he was pretty sure it had been in use at least ten years before that. It was certainly an excellent thing in a tropical climate, where it was utterly impossible to get well-seasoned wood, and he was only surprised it had not been introduced into our artillery long before ten years ago, when it first made its appearance. He had some experience in the wheels of a battery sent out to India at the time of the mutiny, which were found utterly useless, and they had to be taken off; fortunately some were borrowed from a battery belonging to Holkar, which fitted the axles of the English battery, or it would have been utterly useless. He should himself, in the construction of a travelling waggon, be more inclined to adopt the design of the old artillery waggon, or something more in the form of a limber with a waggon attached to it, which was in fact two joined together. In that case you got rid of the perch, which was very liable to fail in a long journey, and had nothing but the two axletree beds and the pole, and the pole of the limber carriage was simply hooked on the axletree bed of the foremost one.

The Rev. E. L. BERTHON said he doubted if Mr. Liggins had ever seen his boats, as they were not supplied to any ships crossing the Atlantic, though they were to Indian troopships. The seamen preferred them as they were set up instantly, and sailed faster than any boats in the world. One had recently made an expedition from the Azores to Southampton, and the last 350 miles was at the rate of ten knots an hour. That was a boat which would have carried seventy men. He had himself been in Algoa Bay in a gale of wind when the *Spartan* had to let go two anchors at once two miles from shore, and the only boat which could be trusted to go off to the land was a Berthon boat. That boat was now six years old, she had never had a farthing's worth of repairs, and was as good now as she was then.

Mr. P. A. MAIGNEN, referring to the question of water supply, and to the statement that mechanical filtration was impracticable, said his filters had been supplied to the Government for use in Egypt, and had proved thoroughly successful. He was now supplying 100 for carrying on pack-saddles, to each of which was sent enough charcoal to renew it 100 times, and another was being constructed for camp use, 4 ft. by 4 ft. and 3 ft., which would filter 1,000 gallons per hour.

Major-General FEILDING, in reply, said there was no wood at all on the Lower Nile suitable for boat-building; on the Upper Nile, the boats were built of acacia wood, the supply of which was very limited, as also were the number of boat-builders, and, therefore, as time was of the utmost importance, it was absolutely necessary that the boats should be built in this country and sent out. He had not thought it necessary to refer to scientific instruments, their use being so obvious; even in Europe a man would take a compass with him if going in a strange district, and naturally in a strange country where there were no roads, and of which, perhaps, there was not even a map, he would take some kind of a sextant so as to ascertain where he was each day. The particular form of compass he preferred was shown downstairs, the dial being made of mother-of-pearl of different colours, which could be always seen, and did not cockle. He always weighed his things when starting, in order to see that the weight was properly distributed. With regard to axles, he preferred the common one, with all the delays it might occasion. The simpler the construction of such a thing the better, and there was always time to grease the axles when necessary. He had already discussed the question of convex tires with Mr. Hooper and Mr. Robinson, and was still rather inclined to it, though he might perhaps be wrong. He entirely agreed that a waggon should be built of the wood of the country, and in Australia he had his waggons built there, though for the wheels he preferred hickory, on account of its toughness, even if not so hard as iron wood, jarrah, and some other native woods.

The CHAIRMAN then proposed a vote of thanks to Major-General Feilding, which was carried unanimously, and the meeting adjourned.

The paper was illustrated by articles exhibited by the following firms:—

Anderson, Anderson and Co., Victoria-buildings, Queen Victoria-street, E.C.—Regulation waterproof cloak; regulation waterproof valise (bed and knapsack combined); portable collapsible bucket, basin, and bath; waterproof top boots.

Berthon Boat Company, Holborn-viaduct, E.C.—Patent folding boat in two parts; combination folding boat and tent.

Bowring, Arundel, and Co., 11, Fenchurch-street, E.C.—The "Combination" pack-saddle, boxes and bedstead.

C. Churchill and Company, 21, Cross-street, Finsbury, E.C.—Cross-cut saws, axes, hatchets, hammers, combination wrench, and other tools.

J. C. Cording and Co., 19, Piccadilly, W.—"En Route" saddle and hand-pack; waterproof poncho ground sheet; regulation bed; Ashantee hammock; improved hammock; "The Land and Water" bag.

B. Edgington, 2, Duke-street, London-bridge, S.E.—Small size double-roofed "Ridge" tent, four-fold, for hot climates, "Suakin" pattern; folding camp bed and other fittings. Models and photographs of various forms of tents.

Firmin and Sons, Limited, 153, Strand, W.C.—Patent "Universal" pot-box for cooking or for use as a steam inhaler or fumigator; new "Hart-glas" wicker and felt-covered water bottles.

J. Forbes-Watson, LL.D., M.D., 16, Lullington-road, Anerley, S.E.—Patent felt helmets with fibre and sponge lining for protecting the head from the heat of the sun in tropical climates.

C. Lancaster, 151, New Bond-street, W.—Colonial breech-loading gun for shot or ball (with hammer); ditto (hammerless); patent four-barrel hammerless pistol, non-fouling, smooth oval-bore rifling, to take regulation ammunition.

P. A. Maignen, 32, St. Mary-at-hill, E.C.—Patent "Filtre Rapide," in various forms suitable for camp and transport.

Patent Waterproof Paper and Canvas Company, Limited, Willesden, N.W.—Samples of paper and canvas treated by the Company's patent water-proofing process. Photographs and model, showing various applications of the waterproof paper, &c., to buildings.

Pfeil, Stedall. and Son, Broad-street, Bloomsbury, W.C.—Warner wheel, having a stock or centre similar to a plain wheel, but with the addition of an iron mortised band, through which the spokes are driven into the wooden stock.

Silicated Carbon Filter Company, Church-road, Battersea, S.W.—Canvas travelling filter; pocket filters.

S. W. Silver and Co., 67, Cornhill, E.C.—"Regina" hammock; ebonite water-bottle and felt-covered water keg; zinc bucket canteen with enamelled iron fittings, cooking stove, &c.; anti-cholera, money, and other belts; pith helmets for tropical climates; Mexican poncho, forming combination coat and ground sheet; Australian saddle, tethering rope, web bridle, and raw hide girth; pack-saddle; explorer's knife in sheath; portable leather medicine case.

Society of Arts, John-street, Adelphi, W.C.—Model of a Cape waggon, presented to the Society by Dr. R. J. Mann.

Louis Vuitton, 289, Oxford-street, W.—Patent folding trunk bed.

War Department, Woolwich Arsenal.—Wheel used for gun carriages.

J. P. Wright, 3, Park-road, Redhill, Surrey.—Patent special explorer's folding boat; model of a collapsible boat.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

H.R.H. the Prince of Wales has fixed Monday, May 4th, for the opening of the Exhibition.

A special railway guide, under the title of the "International Inventions Exhibition Railway Time and Guide Book," is being prepared by Mr. J. R. Somers Vine, the City and official agent of the council. The first issues, to the number of a quarter of a million, will be distributed gratis, copies being sent by post to householders living within 20 miles of the Exhibition. It will contain a small outline map of the railways and stations in and around London, and under the name of each station the average number of trains running thence towards the Exhibition between midday and 8 p.m., the cost, first. second, or third class, of the whole journey, including admission to the Exhibition, the average time the journey takes, the point at which the visitor would enter the Inner Circle from the suburban line, and the time at which he must leave the Exhibition in order to catch either of the last two trains by which he can get home. This is to render easier the working of an arrangement made with the railway companies under which the visitor starting from any place within about 20 miles of the Exhibition will be able to take a through ticket, including admission to the Exhibition, so that he will not have to re-book at any point. Except in the case of those arriving at Fenchurch-street Station, who must walk to Mark-lane to get upon the Inner Circle, visitors once at their own local station will be under cover until they enter the south galleries of the Exhibition through the new subway from the South Kensington Railway Station. This covered way is being rapidly pushed forward, and the excavations have already reached the post-office in Exhibition-road. Here it will turn to the westward, passing to the Exhibition by the rear of the post-office. The objection to the lighting and ventilation of the subway as originally proposed, on the side of the grounds of the Natural History Museum, has been overcome, and a short distance beyond the crossing in Cromwell-road the passage is driven beneath the footpath.

Correspondence.

TEMPERED GLASS.

In your report of Mr. Frederick Siemens's paper read on February 26th, and in the discussion thereon, I see no mention of the fact that the process of tempering glass, as carried on at the Dresden Glass Works for the last six years, was carried on at Stockport in 1877-78.

On March 30th, 1878, I conducted a party of students from the Manchester Architectural Association over the works; and having with me a number of samples, each 6 inches square, of 16 oz., 21 oz., and 26 oz. sheet glass, had half of them tempered by the process of heating to redness and then chilling between iron tables or slabs permeated by cold water tubes. The sheet glass, when so tempered, only broke when the weight fell three times the height (or 9-fold percussion) required to break the usual sheet glass; and a piece of ⅝ in. rough plate resisted a 2¼ lb. lead weight dropped from a height of about 40 ft., or 383 times the percussion which broke common ⅝ in. rough plate. I used some tempered sheet glass for windows of a mechanics' shop, and it well resisted the iron chips from the cold chisels. The manufacture ultimately failed, apparently from not being annexed to a glass works, but being carried on as a separate business.

J. CORBETT.

Manchester, March 10, 1885.

Notes on Books.

THE ANIMAL FOOD RESOURCES of DIFFERENT NATIONS, with mention of some of the special dainties of various people, derived from the Animal Kingdom. By P. L. Simmonds. London: E. and F. Spon. 1885.

The plan of this book is to some extent an enlargement of that of a former work of the author's, "The Curiosities of Animal Food," now out of print, but the substance is entirely new. In his introductory chapter Mr. Simmonds discusses the question of the effect of diseased meat upon the eater, and he then devotes some space to the consideration of the practice of cannibalism. Two chapters are given to flesh food from mammals, extending from monkeys to porpoises, one to food furnished by the feathered tribes, one to eggs, and one to reptiles, snakes, and amphibians eaten as food. The food products of the sea are discussed in two chapters, and the last three chapters are devoted to insects—as bees, ants, caterpillars, and locusts—to crustaceans, mollusca, and radiata. Among the last items of animal food to be mentioned are leeches and earthworms. Besides a full account of the different articles of animal food, this volume contains a large number of statistics relating to production and consumption.

WOOD-CARVING, PRACTICALLY, THEORETICALLY, AND HISTORICALLY CONSIDERED, with Notes on Design as applied to Carved Wood. Edited by Fred. Miller. London: Wyman and Sons.

This is one of a series of technical handbooks, two of which (Pottery-Painting and Glass-Painting) have already been noticed in these pages. The author gives practical directions for the mechanical portion of the subjects, and explains the necessary tools and the characteristics of various woods used by the workman. He then deals with the more artistic side of the subject, and explains some of the chief examples of the two schools of wood-carving, the Gothic and the Renaissance. The volume is fully illustrated.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

MARCH 18.—"The Rivers Pollution Bill." By J. W. WILLIS-BUND. Lord ALFRED S. CHURCHILL, Vice-President of the Society, will preside.

Papers for reading after Easter:—

"The History and Manufacture of Playing Cards." By GEORGE CLULOW.

"The Musical Scales of Various Nations." By A. J. ELLIS, B.A., F.R.S.

"A Marine Laboratory as a Means of Improving Sea Fisheries." Professor E. RAY LANKESTER, M.A., F.R.S.

"Recent Improvements in Coast Signals." By Sir J. N. DOUGLASS.

"The American Oil and Gas-fields." By Professor JAMES DEWAR, F.R.S.

INDIAN SECTION.

Friday evenings at Eight o'clock.

MARCH 13.—"The Present Condition and Future Prospects of Female Education in India." By MANCHERJEE M. BHOWNAGGREE, late Secretary of the Alexandra Girls' English Institution, Bombay. MATTHEW ARNOLD, D.C.L., will preside.

APRIL 17.—"The Parsis and the Trade of Western India." By JEHANGEER DOSABHOY FRAMJEE.

MAY 8.—"The Ancient and Modern Methods of Treating Epidemics of Small-pox in India." By ROBERT PRINGLE, late Sanitary Department H.M. Bengal Army. Sir PHILIP CUNLIFFE-OWEN, K.C.M.G., C.B., C.I.E., will preside.

MAY 15.—"The Golden Road to South-Western China." By R. K. DOUGLAS, Professor of Chinese at King's College, London.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings at Eight o'clock.

MARCH 17.—"The Congo and the Conference, in reference to Commercial Geography." By Commander CAMERON, R.N., C.B.

MARCH 31.—"Kiliman'jaro and the Surrounding District of Equatorial Africa." By H. H. JOHNSTON.

APRIL 28.—"The Federation of the Empire." By J. E. GORST, M.P. The Right Hon. W. E. FORSTER, M.P., will preside.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings at Eight o'clock.

APRIL 23.—"The Chemistry of Ensilage." By FREDERICK J. LLOYDD.

The dates given above are subject to alteration.

CANTOR LECTURES.

Monday Evenings at Eight o'clock.

The Fifth Course, "Carving and Furniture." By J. HUNGERFORD POLLEN.

LECTURE II. MARCH 16.—The Renaissance.

LECTURES III. & IV. MARCH 23 & 30.—The Age of Gibbons, Boule, and that of their successors.

The Sixth Course, "Photography and the Spectroscope." By Captain C. W. DE W. ABNEY, R.E., F.R.S.

April 20 and 27.

The Seventh and concluding Course, "The Manufacture of Toilet Soaps." By C. R. ALDER WRIGHT, D.Sc., F.R.S., F.C.S.

May 4, 11, and 18.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 16...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. J. Hungerford Pollen, "Carving and Furniture." (Lecture II.)

British Architects, 9, Conduit-street, W., 8 p.m.

Medical, 11, Chandos-street, W., $8\frac{1}{2}$ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Mr. W. P. James, "Fossil Botany, and its Bearings on Evolution."

London Institution, Finsbury-circus, E.C., 5 p.m. Lecture by Prof. Norman Lockyer.

Colonial Institute, Prince's-hall, Piccadilly, W., 8 p.m. Sir Frederick Napier Broome, "Western Australia."

TUESDAY, MARCH 17..SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Commander Cameron, "The Congo and the Conference, in reference to Commercial Geography."

Royal Institution, Albemarle street, W., 3 p.m. Prof. Arthur Gamgee, "Digestion." (Lecture III.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Adjourned discussion on Mr. Wm. Stroudley's paper, "The Construction of Locomotive Engines, and some Results of their Working on the London, Brighton, and South Coast Railway."

Statistical, School of Mines, Jermyn-street, S.W., $7\frac{3}{4}$ p.m.

Teachers' Training and Registration Society, 3 p.m. Annual General Meeting (at the HOUSE OF THE SOCIETY OF ARTS).

Pathological, 53, Berners-st., Oxford-st., W., $8\frac{1}{2}$ p.m.

Zoological, 11, Hanover-square, W., $8\frac{1}{2}$ p.m. 1. Dr. F. H. H. Guillemard. "Report on the Collection of Birds made during the Voyage of the Yacht *Marchesa*." (Part I.) 2. Mr. T. Kirsch, "The Butterflies of Timor-Laut." 3. Prof. W. Nation, "Notes on the Peruvian Cliff-Swallow (*Petrochelidon ruficollis*." 4. Mr. Jean Stolzmann, "Observations on the Theory of Sexual Dimorphism."

College of Physicians, Pall-mall East, S.W., 5 p.m. (Croonian Lectures.) Dr. Hermann Weber, "Hygienic and Climatic Treatment of Consumption." (Lecture III.)

WEDNESDAY, MARCH 18...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. J. W. Willis-Bund, "The Rivers Pollution Bill."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. Robert H. Scott, "Notes on Sunshine Records." 2. Paper by the late Mr. Henry B. Joyner, "Results of Meteorological Observations made at San Paulo, Brazil, 1879-1883." Exhibition of Sunshine Recorders, Radiation, and other Meteorological Instruments.

Hospitals Association, 1, Adam-street, Adelphi, W.C., 8 p.m. Re-discussion of the Out-Patients' Question, to be opened by a paper by Dr. J. S. Bristowe.

Archæological Association, 32, Sackville-street, W., 1. Rev. Dr. Eakins, "Ancient Navigation in the Indian Ocean." 2. Dr. Alfred C. Fryer, "Notes on Ancient Glass."

THURSDAY, MARCH 19...Royal, Burlington-house, W., $4\frac{1}{2}$ p.m.

Antiquaries, Burlington-house, W., $8\frac{1}{2}$ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Prof. Allman, "New Genera and Species of Hydroids from H. Gatty's Collection." 2. Mr. William E. Armit, "Plants of Moresby, Basilisk, O'Neill, and Margaret Islands, South East, New Guinea."

Chemical, Burlington-house, W., 8 p.m.

London Institution, Finsbury-circus, E.C., 7 p.m. Prof. Ernest Pauer, "The Pianoforte Composers after Beethoven's Time."

Royal Institution, Albemarle street, W., 3 p.m. Prof. J. Dewar, "The New Chemistry." (Lecture X.)

Historical, 11, Chandos-street, W., 8 p.m.

Ladies' Sanitary Association, 22, Berners-street, W., $3\frac{1}{2}$ p.m. Mrs. Shiel, "Physiology and the Laws of Health." (Lecture IV.). "Circulation."

College of Physicians, Pall-mall East, S.W., 5 p.m. Lumleian Lectures.) Sir Andrew Clark, "Some Points in the Natural History of Dry Pleurisies." (Lecture I.)

Numismatic 4, St. Martin's-place, W., 7 p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Special Meeting. Sir Charles A. Hartley, "The Theory and Practice of Hydro-Mechanics." (Lecture IV.) "Inland Navigation."

FRIDAY, MARCH 20...United Service Institution, Whitehall-yard, S.W., 3 p.m. General Sir George W. Green, "The Employment and Organisation of Camel Corps in Warfare."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Prof. A. W. Rücker, "Liquid Film—a Soap Bubble."

Philological, University College, 8 p.m. Paper by Mr. Henry Sweet.

Mechanical Engineers, 25, Great George-street, S.W., $7\frac{1}{2}$ p.m. 1. Adjourned Discussion on Mr. George Richards' Paper, "Recent Improvements in Wood-Cutting Machinery." 2. Mr. R. Hammersley Heenan, "Description of the Tower Spherical Engine." 3. Mr. Henry Sandham, "The History of Paddle-Wheel Steam Navigation."

SATURDAY, MARCH 21...Royal Institution, Albemarle-street, W., 3 p.m. Mr. C. Armbruster, "The Life, Theory, and Works of Richard Wagner." With musical illustrations. (Lecture IV.)

Journal of the Society of Arts.

No. 1,687. Vol. XXXIII.

FRIDAY, MARCH 20, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Mr. J. Hungerford Pollen delivered the second lecture of his Course on "Carving and Furniture," on Monday evening, 16th inst. He traced the influence of Greek and Roman Art in gradually bringing about the Renaissance, and showed how the various forms of Gothic continued to be used in England to a comparatively late period, owing to the distance of this country from the influences of ancient art. A large number of specimens of carving, as used for doors, panelling, cabinets, chimney-pieces, and ceilings were shown on the screen by means of the lantern.

The lectures will be printed in the *Journal* during the summer recess.

MR. A. J. ELLIS'S PAPER.

The attention of members is drawn to alteration of date for the reading of Mr. A. J. Ellis's paper on "The Musical Scales of Various Nations." The paper will be read on Wednesday evening next, March 25th, in place of Sir Francis Bolton's paper, on "The Introduction of the Beet Sugar Industry into England," previously announced.

PRACTICAL EXAMINATION IN VOCAL AND INSTRUMENTAL MUSIC.

The next Examination in London will be held by Mr. W. A Barrett, Mus.Bac. (Oxon.), at the House of the Society of Arts, 18, John-street, Adelphi, W.C., during the week commencing 8th June, 1885.

Full particulars can be obtained on application to the Secretary.

SOCIETY OF ARTS' PRIZES.

The Council of the Society of Arts are prepared to award the following Gold Medals in connection with the International Inventions Exhibition:—

John Stock Prize.

Under the John Stock Trust, one Gold Medal, for the best application of Photography to a Permanent Printing Process, Group XXVI., Class 140; Group XXIX., Class 159.

Howard Prizes.

Under the Howard Trust, five Gold Medals, for the best exhibits (coming within the terms of the Trust*) in the following Classes:—One for the best exhibit in Group IV., "Prime Movers," Class 26. Steam-engines and Boilers. One for the best exhibit in Group IV., Class 27. Gas and Air Engines. One for the best exhibit in Group IV., Class 28. Means of Utilising Natural Forces. One for the best exhibit in Group XI., Classes 59 to 62. One for the best exhibit in Group XIII., "Electricity," Class 72. Distribution and Utilisation of Power.

Fothergill Prize.

Under the Fothergill Trust, one Gold Medal for the most novel and best exhibit in Group XXVIII., "Philosophical Instruments and Apparatus," Classes 148 to 158.

Alfred Davis Prize.

Under the Alfred Davis Trust, three Gold Medals to be awarded in Division II. of the Exhibition (Music), Groups XXXII. to XXXIV., Classes 166 to 180.

The Council propose to ask the Juries in each Class to recommend for their consideration either two or three exhibits which they might consider deserving a prize. It will not be necessary for any special application to be made in respect of these Prizes.

A full list of the contents of the classes referred to above was given in the *Journal* of January 9th.

* The Trust was left "for the purpose of presenting periodically a prize or medal to the author of a treatise on the properties of steam generally, or any of them particularly, as applied to motive-power, or it may be of air or permanent gases, or vapours, or other agents so applied, or to the inventor of some new and valuable process relating thereto."

Proceedings of the Society.

APPLIED CHEMISTRY & PHYSICS SECTION.

Thursday, March 12, 1885; Capt. ABNEY, F.R.S., in the chair.

The paper read was on—

RECENT IMPROVEMENTS IN PHOTOGRAPHIC DEVELOPMENT.

By W. K. BURTON.

The development of a photographic image consists, in most cases, of a process for strengthening an impression made by light. This impression is, in the greater number of cases, so weak before development that it is quite invisible, and is called the "latent image." Although, in most cases, the process of development may be styled a strengthening one, there are several in which it is something quite different, and, in briefly describing the various methods of development which have been in vogue, the one which we take first is so.

In 1814, Nicéphore Niépce invented a photographic process which may be said to have been the first deserving of the name. He coated white metallic plates with a solution of bitumen in oil of lavender. These were dried in the dark. Now, light has the curious effect on bitumen of rendering it insoluble in oil of lavender. The consequences of this are that, if such a plate as has been described is exposed in the camera, certain portions of the bitumen will through time become insoluble, whilst others will remain soluble. On washing the plate afterwards with oil of lavender, or oil of white petroleum, the soluble parts will be dissolved away, and a picture of some sort will be left on the plate. For reasons that it is not necessary to enter into here, such a picture must be very imperfect.

The process of washing away the soluble bitumen is certainly one of development, although it cannot be said to be one of strengthing the image.

I can illustrate to you a process which is in use at the present day, and in which development is conducted on a principle precisely similar to that on which the development of Niépce's heliographs was conducted. It is known as the carbon process. The film consists of gelatine in which there is a certain amount of bichromate of potassium, and also a certain amount of colouring matter. On bichromated gelatine the effect of light is analogous to that on a bitumen plate. It renders it insoluble in warm water, whilst that not acted upon remains soluble. It is only necessary, therefore, when a film of what is called "carbon tissue" has been exposed to light, to pour warm water on to it, when development will proceed by the washing away of those parts which remain soluble. This I illustrate. It is necessary to transfer the film on to a second surface before development, so as to get at the back of it. A moment's consideration will show that without this no half tone could be got.

We now pass on to a consideration of the various methods of development which come under the definition that I gave at the commencement of the paper. The first of these which I consider worth noting is that of the daguerreotype. In the daguerreotype the film is supported on a surface of pure metallic silver. It consists of a thin layer of iodide of silver, or a mixture of iodide and bromide and chloride of silver, produced by exposing the silver surface to iodine, bromine, or chlorine vapours. The image produced in the camera is so weak as to be invisible, yet it is capable of attracting particles of mercury in such a manner that, if an exposed plate be treated with mercury vapours, the minute globules are attracted to certain portions of it till a complete image is built up.

The story of the discovery of development by Daguerre has been told so often that probably all here have heard it. Moreover, its authenticity is, to say the least of it, doubtful. Still it is so pretty that I cannot resist the temptation to repeat it. It is said that Daguerre, whilst working his process in its original form, wherein such a length of exposure was given that the image became visible in the camera, accidentally exposed some plates for too short a time. He placed them in a cupboard as useless, except for cleaning at some convenient time for future experiments. On returning, after a space of time, to remove the plates, he was astonished to find a distinct image on each of them. He was almost inclined at first to attribute the phenomenon to magic, but on second thoughts determined to investigate it. He was acute enough to guess that the effect must have arisen from one of the chemicals, of which there were several in the cupboard. He, therefore, continued to place under-exposed plates in it, removing in each case one chemical as he did so, till at last only

an open bottle of mercury was left, or, as some say, till all the chemicals were taken away, when Daguerre discovered that some mercury had been spilled in the cupboard, and had run into the cracks on the shelves.

In the experiment which I am about to perform, I wish to show you very distinctly a case in which the action of the developer is that of strengthening the image. It is the platinotype printing process. In this process, paper prepared by the application of certain salts—amongst which is a salt of platinum—to its surface, is exposed in a printing frame behind a negative. The light has the effect of producing a faint image. This can be seen in the print handed round. The effect of floating the paper with this faint image on a hot solution of oxalate of potash, is to produce instantly a bold and vigorous image which consists of metallic platinum. I do not wish to go into the question of the chemical changes which take place, because they are not particularly well suited to illustrate a case of simple development, the salt which is acted upon by light not being the one which is subsequently reduced by development. I think, however, the manipulation of a platinotype print forms the very best illustration of development that we could possibly have.

Going back again to developers, in the order in which they were introduced, I shall take the liberty of passing over all between that of the daguerreotype and that by an acid solution of pyrogallol. This latter may be taken as, in a certain sense, typical of all developers that have ever been since used, and I shall try to make its action clear; but, first, I must briefly describe the collodion process, in conjunction with which it was used. In this process the film consists of iodide of silver, or, generally, both iodide and bromide held in suspension, in a very fine state of division, in collodion. This film is produced by coating a plate with collodion, having dissolved in it iodide of cadmium, or some other soluble iodide—for the sake of simplicity, I disregard the bromide which commonly accompanied the iodide—and dipping the plate into a bath containing a solution of silver. nitrate. The silver nitrate produces iodide of silver in the film by double decomposition with the soluble iodide. When the plate is removed from the bath, the film contains in it this iodide of silver, and on it a solution of nitrate of silver. In this condition it was exposed in the camera. A latent image was the result. As to the precise nature of this image, there has been much discussion. Captain Abney states that it is sub-iodide of silver, and I have no doubt that he is right, but it is unnecessary to enter into the question here. When the plate has been exposed, there is flowed over it the developer, consisting of an acid solution of pyrogallol. Now, observe what takes place. The pyrogallol, or, to adopt the abbreviation common amongst photographers, the "pyro," has a strong affinity for oxygen. In the water, the symbol for which is H_2O, there is an atom of oxygen ready to go to the pyro if there happen to be anything near to take up the hydrogen. This desideratum is supplied by the nitrate of silver solution which, it will be remembered, is on the collodion film. Nitrate of silver is expressed by the symbol $Ag\ NO_3$. In presence of this nitrate of silver the hydrogen of the water goes over to the NO_3, forming H, NO_3 or nitric acid. The Ag., or silver, is set free. This action is illustrated by pouring into a solution of silver nitrate a solution of pyrogallic acid; very soon a black precipitate is noticeable; this is metallic silver. The action is represented by the following equation:—

$$\text{Pyro} + H_2O + 2\,(Ag.\,NO_3) =$$
$$\text{Pyro}\ O + 2\,(H, NO_3) + Ag.$$

I have in the above written "pyro" in place of the formula $H_3\,C_6\,H_3\,O_3$.

It will be understood, then, that on this wet plate there is produced, by the action of the developer on the nitrate of silver, a black powder of silver, such as has just been produced in this glass jar. The latent image has the power of attracting this silver just as the latent daguerreotype image has the power of attracting mercury, and so an image is slowly built up on the plate. I illustrate this by developing a transparency on a wet plate in a cell in the lantern, the image being thrown into a screen. The negative for this was kindly lent me by Mr. Edward Sharp, of 221, Westminster-bridge-road. The developer used is not the acid pyro one, but is one which acts in precisely the same manner, that is to say, by its powers of attracting oxygen, and every modern developer that I know of for the development of plates also acts in the same manner.

The function of the acid in the solution is to restrain the action, to cause the silver to be deposited so slowly that the latent image has time to pick it up. The action of a neutral solution of pyro is more vigorous than that of an acid one, the action of an alkaline solution is still more vigorous. It was supposed, until

the year 1861, that pyrogallic acid would not act directly on either iodide or bromide of silver; but in that year, it was discovered that a neutral solution would reduce bromide of silver. This was a turning point in the matter of developers; without it we could not have the rapid processes of to-day. In the year 1862, it was discovered that an alkaline solution of pyro was still more active, and that by its use an image could be developed on a plate containing bromide of silver, but on which there was no free silver nitrate, the image in this case being produced by the reduction of the silver salt actually in the film.

From the time of the discovery of development by the reduction of the silver salt in the film, we may take a leap to the present time, for with the present dry processes such developers are used. Of these modern dry plates it is surely sufficient to say that they consist of films of gelatine, holding in suspension minute particles of bromide or chloride of silver, or a mixture of these two, or of bromide and iodide of silver, or of bromide, iodide, and chloride of silver.

When we come to treat of the modern dry-plate processes, we have commenced on what may fairly come under the actual title of my paper, namely, "Recent Improvements in Photographic Development."

Let me say at once on this subject, that in my opinion there has been no actual improvement since it was discovered that an alkaline solution of pyrogallol acts as an active developer on the haloids of silver. I wish it to be understood that here I am merely only expressing my own opinion. Developers differing widely from the "alkaline pyro" have been introduced of late years by our chairman and others, and there are many who prefer these to my own favourite. Moreover, even when stating my preference for alkaline pyro, I refer only to the ordinary work of developing gelatine dry plates. There are other purposes for which more recently discovered developers are far more useful.

From the time when the alkaline pyro was discovered, we may at once pass on to the announcement by Mr. Carey Lea, in 1877, that certain organic salts of silver, and notably ferrous oxalate, are as energetic developers, even in the neutral state, as alkaline pyrogallol.

I find that, in 1878, Captain Abney, in speaking of ferrous oxalate, mentioned that "the ferrous citrate of iron and ammonia is also effective" as a developer. It is this developer the action of which I wish to show you now. I have here an exposed gelatino-chloride plate prepared by Mr. A. Cowen. This I dip into a bath of ferrous citrate of iron solution, when the development will be seen to proceed.

The next discovery in the way of a developer was that of hydrokinone. This substance takes the place of the pyrogallol in a developer. It is less vigorous in its action, and, as a consequence, can be used without the restrainer which is always necessary when pyrogallol is used with ammonia—which latter is the alkali commonly employed. Hydrokinone was suggested as a developer by Captain Abney about three years ago.

About two years ago, Mr. L. Warnerke brought forward a matter in connection with development, which was certainly a complete novelty. He discovered, or at any rate first made use of the discovery, that when a gelatine plate is developed with alkaline pyro the gelatine is rendered insoluble where the film is darkened. He made use of this fact to get rid of all the useless gelatine, which, in ordinary circumstances, is left in the shadows of the negative. He supported his films on paper. These were transferred, after development, to a "temporary support," precisely as you saw me transfer the carbon print. They were then treated with warm water again, precisely as the carbon print. By this means an image of very great purity was produced, and one which could be intensified in a far more satisfactory manner than can those from which the superfluous gelatine has not been removed. The process of Mr. Warnerke appeared a very promising one, but I am not aware that it has been largely adopted. Probably the trouble involved in working it was thought too great.

A few months ago, Mr. Arnold Spiller suggested hydrochloride of hydroxylamine as a developer. Of it there may be said very much the same as has already been said of hydrokinone, and in addition to this, that it gives negatives of a very fine colour.

In talking of the alkaline pyrogallic developer, I have so far said nothing of the alkali to be used with the pyro. Until quite recently it was the universal—or almost universal—custom to use caustic ammonia as the alkali, at any rate for gelatine plates. Lately, however, there have been many champions of other alkalies. Some have raved about washing soda, and others have gone nearly mad about caustic potash. It seems certain that photographers settled down to the use of

caustic ammonia without making sufficient experiment as to whether other alkalies might not be more suitable. The alkalies which are practically available for developing with pyro are the following:—Caustic ammonia, caustic potash, caustic soda, carbonate of ammonia, carbonate of potash, and carbonate of soda.

I have tried all these alkalies, and have with me here plates developed by means of each of them. I have been greatly assisted in my experiments with these various alkalis by the information given in an article in the "British Journal Photographic Almanack" for the present year, in which the editor, Mr. W. B. Bolton, gives the results of almost innumerable experiments conducted by him on the alkalies mentioned. I am further indebted to him for a table showing the alkalinities of the various salts experimented with. This table is so valuable, that I think I cannot do better than append it entire as he gave it to me. The last column may require a word of explanation. If solutions, each constituting of a hundred parts by weight, be made up with the alkalies mentioned, the number of parts given in the last column being in each case used, the solutions will all be of the same alkalinity.

Solutions of Alkaline Carbonates and Caustic Alkalies of equal Alkalinity.

Based on the standard of a 10 per cent. solution of washing soda.

		Symbol.	Equiv.	Parts in 100 of solution (by weight).
1	Caustic ammonia	NH_3	17	·5944
2	,, ,, solution 59·958, containing 10·65 per cent. NH_3	..	..	5·5812
3	Potassium hydrate	KHO	56·1	1·9615
4	Sodium ,,	NaHO	40	1·3986
5	Ammonium carbonate	(NH_4) 2 CO_3	96	3·3566
6	Potassium ,, anhyd.	$K_2 CO_3$	138·2	4·7972
7	,, ,, cryst.	$K_2 CO_3 + 2 H_2O$	174·2	6·0909
8	Sodium ,, anhyd.	$Na_2 CO_3$	106	3·7063
9	,, ,, cryst.	$Na_2 CO_3 + 10 H_2O$	286	10·
10	,, ,, (washing soda)			
11	,, and potassium carbonate, anhyd.	$Na K CO_3$	122·1	4·2692

N.B.—In the case of the carbonates, the calculations are founded on the displacement of one atom of the base, and the formation of the acid-bicarbonate thus:—

$$2 Na CO_3 + H_2 C_2 O_4 = Na_2 C_2 O_4 + 2 (Na H CO_3).$$

The latter must be considered as a restrainer, whence it follows that there is no possibility of comparing, caustic and carbonated alkalies in relation to their alkalinity and developing power.—

I have here transparencies developed with pyrogallol, rendered alkaline by all the different salts in the above table, with the exception of the last, developed by hydrokinone, hydrochloride of hydroxylamine, by ferrous oxalate, and also by pyro with ammonia, and with carbonate of ammonia, each with the addition of sulphate of soda. Sulphite of soda was suggested as an addition to the alkaline developer by Mr. Herbert Berkeley in 1881. It has the effect of preventing the formation of the yellow veil or fog which is very common in the case of negatives developed with alkaline pyro, and without the addition of sulphite.

Taking the six transparencies developed by the caustic and carbonate alkalies and pyro without further addition, I may say that I give the first place, by a considerable way, to that got by the aid of carbonate of ammonia. This leaves, I think, nothing to be desired. The colour is as good as can be got by the addition of sulphite, or by the use of ferrous oxalate, and there is any amount of "pluck" in the transparency. Next to carbonate of ammonia comes, in my opinion, our old friend caustic ammonia. Then come the carbonates of potassium and sodium, and lastly, the caustic potash and caustic soda.

I cannot finish without a word about the new rapid printing paper. This is a paper coated with an emulsion of chloride of silver, or

chloride mixed with bromide. The exposure is comparatively short, and the development is by weak and greatly restrained ferrous oxalate. An enlargement which I have here, and which is kindly lent by Messrs. Marion and Co., illustrates the beauty of the results that can be got with this paper.

DISCUSSION.

A MEMBER asked what was the best proportion of sulphite of soda to add to the pyrogallic solution?

Mr. DEBENHAM said he was much interested in the story of the supposed accidental discovery by Daguerre of the effect of mercurial vapours, and he should like to know if it were a fact that mercury would volatilise at ordinary temperature, without artificial heat, sufficiently to develop a daguerreotype image?

Mr. ENGLAND, in reply to the first question put, said he always used five grains of sulphite to one ounce as a developer.

Mr. DEBENHAM said it would be inferred from the paper that pyrogallic acid did not act properly without a restrainer, such as bromide; but he had had some plates, not slow ones either, which gave such a very intense image that, in order to overcome that, he tried to develop them without using any bromide, and a very fair quantity of ammonia, and got a very good image indeed. It, therefore, evidently depended on the particular make of plate whether bromide was necessary. Generally, he preferred using even larger quantities of bromide than were usually recommended.

Mr. ENGLAND recommended, in the development of landscapes, beginning with a very weak developer at first, as in case there might have been overexposure, it could be more easily rectified.

Mr. H. TRUEMAN WOOD suggested that the Chairman should give his opinion as to the comparative value of the different developers Mr. Burton had mentioned. His own belief was that the conclusion Mr. Burton arrived at was the right one—that it did not very much matter which particular alkali was used in the developer; and that, as long as Opie's prescription was followed, and you mixed the developer with brains, the ingredients were not of so much importance. He thought the negative shown as an instance of development with hydrokinone hardly did justice to that process, as he had seen much better results produced.

The CHAIRMAN said the paper was a most admirable one, but on one point he should be inclined to join issue with Mr. Burton, and that was as to the definition of a developer. He thought he should have drawn a distinction between the two kinds of development which he had shown. In the case of a platinotype print, development took place by the substitution of one chemical for another, almost in equivalent proportions. The amount of platinum reduced by the developer, which in this case was potassium oxalate, was measured by the amount of iron in the paper which was reduced by the action of light. In the other mode of development, which was shown on the screen, there was no limit to the amount of silver which might be deposited on the image. Thus the intensity of image in one case was controlled by the circumstances of the action of light alone, and in the other by the action of light plus the length of time you chose to give to the development. He might, perhaps, be hypercritical in making these remarks, but it was just as well to keep this distinction in view. A very pertinent question had been asked by Mr. Debenham, whether mercury would volatise at ordinary temperatures. There was no doubt of this, as those who had made experiments with a Sprenge pump, where it was necessary to get rid of any extraneous substances, would know perfectly well. For instance, Mr. Crookes, in his very elaborate experiments directed to producing vacua in glass tubes and globes, found it necessary to interpose gold foil between the glass globe and the mercury pump, the gold foil absorbing the mercury vapour very rapidly, and prevented it passing over into the vessel which was being exhausted. Not only would this happen in vacuo but at ordinary atmospheric pressures, of course to a very small extent, but probably quite sufficient to develop a daguerreotype plate, in which the image could only be counted by millionths of a grain, and probably but very few millionths of a grain of mercury would be sufficient to develop such an image. One point mentioned by Mr. Burton he was not previously aware of, viz., that pyrogallic acid in a perfectly neutral state would develop an image. He had never been able to demonstrate that absolutely himself, and had never developed an image unless the pyrogallic acid was slightly alkaline, or there were something in the film which tended to make it alkaline. In the days of the old collodion dry plates, you developed with plain pyrogallic acid, but then you had a minute excess of silver left in the plate, and pyrogallic acid was capable of reducing the silver to the metallic state, more particularly when in contact with an image formed by the action of light. No doubt, however, Mr. Burton was able to give chapter and verse for his statement, and he should be glad to hear the particulars of the experiments. Protosulphate of iron was a developer for dry plates in a certain sense, *i.e.*, if it were used at the same time that light was acting on the plate; if used afterwards, it did not act as a developer. He must say he had felt a shade of disappointment in seeing the hydrokinone negative, because, as Mr. Wood had said, he

had seen better. If Mr. Burton had not worked much with this developer, this result was easily accounted for, for it required as much petting as any other favourite. A much better result was attained if carbonate of potash without any restrainer were used instead of ammonia. There would be no stain at all on the negative, which would be a beautiful clear black, with very transparent shadows. This was the developer he preferred to use, and for bringing out an image with a short exposure it was superior to any other. Mr. England had given a valuable hint with regard to using a weak developer for bringing out a landscape at first, and then afterwards strengthening it if required. His own practice was, when he had a plate of which he did not know much, to use a weakish developer, and, after immersion for ten or fifteen seconds, when the plate was fairly soaked, to take it out of the bath, rest it on the dish, and allow it to come out of its own free will. By that means you got, as in the days of collodion, a phantom image, not dense, but which was readily intensified to any required density.

Mr. DEBENHAM remarked that his question was, not whether mercury volatised at ordinary temperatures, but whether it would do so to a sufficient extent to produce the result stated.

Mr. ENGLAND said he had exposed a daguerreotype plate in the usual way, placed it in the evening in the mercury box, and allowed it to remain there until next morning without applying any heat, and it produced a fairly developed image. By then applying a gentle heat, he brought out a very perfect negative. He had no doubt that had the plate simply remained over the mercury for two or three days at the ordinary temperature, it would have been fully developed.

Mr. WERGE said he could confirm the Chairman's remarks. Many years ago he used to find that a daguerreotype picture was very well developed by simply placing a metal plate, smeared with a small amount of mercury, almost in contact with the exposed plate, and carrying it for a few hours in the vest pocket.

Mr. DEBENHAM remarked that the plate would hardly be at the normal temperature in the vest pocket.

Mr. WERGE added that, according to the story of Daguerre's discovery it took place in the summer time, when the heat in Paris would be considerably above that required to volatise mercury. He had not the least doubt the picture was developed in the way described.

Mr. BURTON, in reply, said he could not quote a better authority, as to the proper proportion of sulphite in a developer, than Mr. Herbert Berkeley, who introduced this method, and recommended it as the best; he used four grains of sulphite to every grain of pyro. He could not throw any light on the mercury question, beyond stating the fact that mercury did volatilise at the ordinary temperature, for if you left a little in an evaporating dish for a few months or even less, it would disappear. With regard to the use of the pyro developer with ammonia, and without a restrainer, although he had had plates which would develop in that way, it was the exception, not the rule. If you could always have plates such as Mr. Debenham mentioned, which would develop easily, using a sufficient quantity of ammonia, but no bromide, it would be a great advantage. With carbonates you could always do without a restrainer. With such a plate as Mr. Debenham mentioned, it would be impossible to develop with carbonates, as you could not get a sufficiently strong alkaline solution; but with the usual run of commercial plates, you could develop with carbonate of ammonium without a restrainer; with the other carbonates it was an advantage to have a very small quantity of restrainer. All would agree with Mr. England in advocating the use of a weak developer at first, when dealing with a plate the exposure of which you were not quite certain of. If you were not sure about the exposure, you should build up the image very slowly, beginning with pyro and bromide, and the minimum of ammonia, or even, for a little while, with no ammonia at all, and keep gradually adding ammonia, and building up the image. He ought, probably, not to have shown the hydrokinone transparency at all, for he must plead guilty to not being greatly experienced in working with hydrokinone. When it first came out he tried it with fair results; since then he had not tried it till lately, but had seen good results announced by many operators. About a fortnight ago, he thought he would try this mode of development, and did so in every way he could conceive, with and without restrainer, with ammonia and with other caustic alkalies, but he had not got any good results. This must probably either be owing to his own bungling, or to his having a bad sample of the article. The distinction which the Chairman had drawn between the two modes of development was important, and he was glad it had been mentioned. With regard to the use of non-alkaline pyro, he could certainly give chapter and verse for his statement, the matter having been very fully discussed in the photographic papers in 1861. He had not tried it himself, but he drew the conclusions, from reading about forty or fifty communications, that it certainly was possible to develop with neutral pyro, he imagined with much longer exposure than when using alkaline pyro. The article he took as his chief authority was one by Mr. Wharton Simpson, in which he gave minute details of not only washing out all the nitrate of silver, but of the decomposition of any nitrate of silver which might be left by either a soluble iodide, or chloride, or bromide, and then using a solution of alkaline pyro, which he said was absolutely neutral, and he said that thereby he was

able to develop a picture with all detail but with insufficient density.

The CHAIRMAN then proposed a vote of thanks to Mr. Burton for his very interesting paper, which was carried unanimously.

INDIAN SECTION.

Friday, March 13, 1885: MATTHEW ARNOLD, D.C.L., in the chair.

The paper read was—

THE PRESENT CONDITION AND FUTURE PROSPECTS OF FEMALE EDUCATION IN INDIA.

By MANCHERJEE M. BHOWNAGGREE,
Late Secretary of the Alexandra Girls' English Institution, Bombay.

Thirty years ago, in the memorable despatch of the Court of Directors of the East India Company to their Government of India, in which they recognised it as one of their sacred duties to be the means of conferring upon the natives of India those vast moral and material blessings which flow from the general diffusion of useful knowledge, they expressed their sentiments on the subject of female education thus—

"The importance of female education in India cannot be overrated, and we have observed with pleasure the evidence which is now afforded of an increased desire on the part of many of the natives of India to give a good education to their daughters. By this means a far greater proportional impulse is imported to the educational and moral tone of the people than by the education of men. We cannot refrain from expressing our cordial sympathy with the efforts which are being made in this direction. The Government ought to give to native female education in India its frank and cordial support."

Though forcibly expressed, this was nearly the whole reference to the subject of female education contained in that elaborate despatch which reviewed the past and organised the future educational administration of India; and it reminds me of a somewhat trite phrase in my vernacular Gujarati, which says:—"*Thodè lakhvè ghanu karí jànjo*," meaning, "Know much from the little that is written." But I do not, for one moment, complain that that despatch deliberately fell short of the intention or the policy to which it gave expression; for the reason of the brevity of the treatment given to female education, apparent as it is to those who have had occasion to critically study that masterly paper, is further made plain in a later despatch, that of 1859, which, while repeating the cordial sympathy of the authorities here with the cause, recognised the difficulty of attempting rapid strides in India, and the risk of exercising official pressure in a matter which they rightly regarded as one of extreme delicacy. In this they no doubt did wisely, but not too well. Having expressed their cordial sympathy with the matter, they left its further development to the local authorities in India. On the other hand, the vigorous measures defined in the despatch demanded such immediate and earnest action on the part of the local officers, that the claims of female education were left in abeyance. Numerous causes, some having their source in the prejudices of the people, others in their unwillingness and apathy, furnished a valid excuse for this inaction. These causes, to which I shall have to refer later on, are most of them still existing; and, although the difficulty of removing them is probably much lessened now, it certainly was not insuperable in 1854. And I have opened this paper with an allusion to the despatch of that year, in order to express my humble conviction that, so far as Government is concerned, it has yet to promulgate its advocacy, and to organise and direct the working of female education specially, as distinctly as it did of education generally thirty years ago. Would it be too much to expect that one of the results of the Education Commission of 1882 would be the issuing of such a mandate which might secure to the cause of female education the active and substantial support of the departments of public instruction throughout India?

Having thus briefly noted that female education has missed, as yet, that fair start which was given to the instruction of males, I propose to take a hasty retrospect which might enable us to determine with accuracy the stage at which the former has now arrived. And the first question that strikes us as we proceed on this inquiry is—Has the ignorant condition of the women of India the warrant of antiquity, or is it a morbid growth of extraneous influences of later times? The answer is not doubtful. It is based on reliable facts of history. The women of Hindostan, like the women of other Oriental countries in the days of their greatness, were the compeers of their husbands and brothers in arts and even in arms. The last war of the Persians against the bearers of "the Koran or the Sword" was

fought by their women twelve hundred years ago. About the same period a Queen of Bokhara decisively checked the encroachments of the Arabs. In China, in Corea, in Annam, from remote periods, women have made successful rulers; and in the first named country, even at this day, the affairs of State are guided by the Empress Regent, as they had been before her time by the late Empress Regent. And in India the greatness of women, dating from the remote ages, was handed down to comparatively modern times, when even from the zenana and behind the purdah kingdoms were governed and dynasties established or overthrown. At the present day the Begums of Bhopal are known to us all as capable and intelligent rulers, holding a conspicuous place for wisdom and tact among the independent chiefs: within the present decade the complicated affairs of Baroda were, to a great extent, managed under a woman's direction; and most of the Rajput houses, since their stability began to be impaired by the imbecility of their men, have been propped up from generation to generation, even unto the present day, by the intelligence and shrewdness of their female members. But events and facts of this class, interesting as they are in the highest degree, are not within the scope of our subject to-night; nor would the limits of this paper allow me to diverge into a descriptive account of those Sanskrit and Arabic traditions which record the literary merits and achievements of women of antiquity and of the historic times. Suffice it to recollect that the women of India, whatever the depth of their ignorance in recent times, and however low the state of their education now, are descended from an ancestry which held in high esteem the enlightenment and instruction of females. To the pernicious system of the zenana, which came into vogue with Mahomedan supremacy in India, and to the still more evil mistrust of the Moslem which denied to women the privilege of writing, may be in a great measure attributed the decline, almost the effacement in many parts, of the taste for female instruction which struck the British as they established themselves in India. But all through this period of stagnation, naturally the Indian mind seems to have been instinct with a sense of the dangerous folly of allowing women to lapse into complete ignorance; indeed, the very intercourse of life, in many cases made it impossible from within that they should be entirely engulphed in the wave of ignorance which the pride and prejudices of Mahomedan conquerors directed against them. Among aristocratic houses, circumstances happened very often which required the supervision and personal acquaintance with the management of large estates and other important interests on the part of its female members. Here elementary education, supplemented by experience, did its beneficent work, and many a family narrative often tells how, in Bengal and in the North-West, in the Punjab, in Central India, in Madras, in Bombay, in fact, all over the country, women managed large zamindaries and properties during the minority of the owners, or saved them from burdens and impending destruction brought on by the stupidity or indolence of their husbands or sons. Among the lower population, again, comprising a large number and variety of tradespeople, women appear to have always assisted their husbands in business; and even among those castes on which is enjoined, or rather which erroneously submits itself to, the seclusion of women more rigorously than others, the sight is not unusual when a husband, or brother, or son takes his instruction as regards the price, measure, or weight of articles asked for by customers by a sign or a whisper from his more intelligent relative seated behind a door or a screen. It was in the middle classes that ignorance of women became most fashionable for a time. But never could it be said of India generally, in the sense that we could say of an uncivilised country, or of Egypt, or Arabia, that its womankind was hopelessly buried in ignorance, or that it held in unconquerable detestation the influence and claims of education. Even at a time when that influence and those claims were greatly disregarded, as we have just seen, women of the higher classes beguiled their weary hours by deriving, from behind the purdah, a knowledge of the noble legends and morals recited in their sacred books, from the mouth of the family *bhat*, a religious bard or mendicant; while the girls of the trading or working classes learnt, up to a very young age, their spelling of words and multiplication tables with boys, under the *gooroo* or *puntuji*, the town or village schoolmaster.

I believe the instruction of females stood at this level in the days when British rule in India became a recognised historical fact. And here we may consider in brief the causes which had contributed to its suppression, which held it in check for a considerable time, and some of which still hinder all action for its development. The complete indifference of the people to the instruction of females

may with accuracy be traced to that general confusion to which the country was reduced before the Mahomedan domination was established over the Empire; and all through the period of that supremacy, the position of women and their intellectual growth were reduced to a degrading depth. When it became profitable for the subject races to respect the feelings and please the tastes of the rulers, the sanction of religion, as usual, stepped in, and that which was in a manner first forced became in time fashionable, and ultimately ordained. Other causes combined, meanwhile, to throw additional difficulties in the way; the disordered state of the country, the disunity of interests between men of the conquering race and the other inhabitants, the blind observance of class distinctions, the renewed vigour with which early marriages and the life-long oppression of widows were persevered in; these, and a score of other demoralising practices which had taken root in the country, and now seemed to swarm in upon the people, all tended to lower the condition of women, and education, for its own sake, became for them an indelicate pursuit. The intellectual culture of men had, in the unsettled feeling of the times, greatly dwindled, and they ceased to care for that of the women. False notions of rank and position crept in, the word *moglai* itself became synonymous with exaggerated ideas of vainglory and pomp, and one method of indulging this false pride which became usual and general among all classes was the marriage of children. This custom acquired such a strong hold on the people, that it reigns in all its pernicious rampancy even at the present day. It is considered a grave scandal, attaching to all the members of a family, if a girl grows out of her childhood without being married; and in most castes widowhood is considered a less misfortune than spinsterhood, if the girl crosses that period of life single. Early marriages thus leave no time even for a feeling of uneasiness to be entertained for the uneducated condition of the girls; it furnishes pretexts, on the other hand, for their withdrawal from all instruction, because they are either going to be married or have reached a marriageable age, and should therefore be consigned to the bashful etiquette of the purdah. Thenceforth they breathe its foul confined atmosphere bereft of all healthful contact with the outside world, and regarding its concerns, and the necessity of receiving and imparting information thereon, with stolid indifference. Besides these, the modes of life and the domestic habits of the people have had more or less influence in retarding the development of female education; other causes, too, more of a local than a general character, have very often arrested the progress of promising movements, but it would serve no purpose to dwell on these at any greater length here, and those of them to which your attention is worth drawing will be alluded to later on in their proper connections.

So far, then, we have seen that although the means of instructing the female mind had been for a considerable time restricted, and the condition of women degraded, the notion of female education was never foreign to the soil. There were imbedded in it the germs which might still come to new life with sympathetic nurture; there was the history of the past, now a mere memory, but still influencing the popular sentiment, still arresting men's minds to compare the existing order of things with that of the past, and guiding them to choose, if but those in power encouraged them. That sympathy and encouragement came once again in the train of British administration. With growing acquaintance with the British, as people realised more and more the friendly nature of England's mission in India, they freely acknowledged and appreciated the excellence of European thought and institutions, and perceived in the new importation of Western enlightenment traces of their own civilisation of a former day. Even as early as the close of the last century, in Bombay and Madras, and probably other important stations, a few young men, more ambitious than others, had entered schools conducted by regimental teachers; and very soon afterwards those noble efforts of missionary societies commenced in numerous centres, which gave vitality and breath to the spirit that had been thus kindled. The education of boys on an English basis having been commenced, there followed, naturally enough, at no distant date, a desire for the education of girls. But for a long period it was a desire and nothing more. The programme of missionary operations did not, indeed, exclude the instruction of the girl; but the suspicion which, unfortunately, always attached to their philanthropic labours, combined with those other causes which we have already considered, withheld encouragement to attempts in that behalf. In some instances, Indian girls did come under their teaching, but these were daughters of native converts to Christianity, a body of people very small, and

so rigorously excluded from contact with their fellow countrymen, that it would be inaccurate to connect the circumstance with the development or even the beginning of female education as a whole. In course of time, however, the class of men under the new training rapidly multiplied and gathered force; the desire which had been felt was by them regarded as a distinct want, and, ultimately, efforts were commenced, small, but genuine, for supplying it. From the description and statistics furnished by the excellent report of the Indian Education Commission of 1882, to which in the course of this paper I shall have occasion to refer more than once again, we can gather authoritative information as to their progress and results. It is an interesting digest of the testimony of witnesses competent, from their own experience and knowledge, to speak of the subject, as well as of the history of many institutions spread over numerous documents and reports.

I shall now sketch briefly, and in mere outline, the growth of the efforts of which I have spoken, making references, as short as possible, to those few prominent academies which have sprung from them, and to which is now confided the higher education of girls. This will bring us to the close of the first portion of our subject, namely, the present condition of female education.

Southern India, it seems, was the earliest to enter the field, mainly owing to the fact that missionary enterprise found a larger sphere of action there than in other parts of the country, and a great number of men who did not change their religion took benefit, nevertheless, of the schools founded by them, and were thereby enabled to appreciate and enter into sympathy with their endeavours to improve the status of the people. When, just forty years ago, the first girls' school, partly under native management, was started, there were already in the existing missionary schools female children of a small section of Hindus of the higher castes. A number of schools, some under the management of Europeans and natives, others under that of natives alone, and mostly under the control and inspection of Government, came now into existence, and the progress of the girls had, by 1858, arrived at a stage which made it desirable to have an examination for the award of school-mistresses' certificates. In that year, too, another strong impetus was given by admitting girls' schools to the benefit of grants in aid, when among 39 schools, with 1,185 pupils, a sum of Rs. 1,589 was given. This was a very small but an important beginning, for it was, I believe, the first step towards the definite recognition of the claims of female education to State support. In twelve years more, the figures multiplied, and we find a sum of Rs. 25,682 given to 138 schools, consisting of 7,245 girls; and in the course of a further period of ten years, the number of schools stood at 557, and of pupils at 35,000, the total expenditure being over two and a quarter lacs of rupees. The prominent features of the educational system of Madras, as distinguished from those of the other d' tricts, not excepting Bombay, is that it has a highly efficient organisation, a fuller vitality appears to pervade that system, and the action of Government officers and the co-operation of the people are more responsive to one another. Enlightened interest like that of the Mahraja of Vizianagram, whose name is associated with a number of schools doing substantial work; of the late Princess of Tanjore, who, we are told, having "taken great care to educate herself," was always ready to support the cause; of the Prince and Princess of Arcot, and of many others, has been cordially supported by those in authority, and welcomed by those in whose behalf it is exerted. We have the noble example of Lady Hobart, who, during her husband's administration of Madras, took warm personal interest in education, particularly that of the Mahomedan women, probably because she found them in a more backward state than those of other races, and who gave tangible shape to that interest by founding a school for them. Mrs. Grant Duff, the wife of the present Governor, seems to be equally zealous, as the local papers almost every week testify; and as one wades through the reports of public instruction in Madras for recent years, one is agreeably struck with the fact that the successive heads of that department have made the development of female education a matter of special and indulgent care. A number of normal and practising classes are in active operation; the inspection of female schools is entrusted to competent women specially appointed for the work; and all throughout the Presidency the signs of a healthy infantile growth are perceptible. It is pleasing to note this fact from such interesting statements as the one contained in the report for 1882, which says:—"The work done by the inspectress during the year has been greater than in the previous year. The number of schools examined rose from 143 to 162, and the pupils examined from 5,150 to

5,947. Mrs. Brander spent 72 days in examining work, and 67 days on circuit, and travelled nearly 2,300 miles." We have it again on more recent authority that now, at the beginning of this year, "the number of girls being educated was twice as large as it was three or four years ago. There were now 60,000 girls in the various schools against 30,000 about four years ago. . . . There were three normal schools then, and by the end of this year there would be eleven at work."

As the Church of England Society and the missionaries of the Scottish Church had initiated the movement in Madras, so it was another similar body that began the work of female education in Bombay. It was the American Mission. The efforts of this body, supplemented by those of the two previously named, went through a similar process, and brought about much the same result as in the case of Madras, namely, to impress the young men trained under the new system with a sense of the want of female education. A number of Parsee youths, the first and hitherto perhaps unsurpassed batch of students turned out by that institution which commemorates the name of one of the best and the most far-seeing governors of Bombay, the Hon. Mountstuart Elphinstone, paved the way. The prominent students of this institution had, with the co-operation of their professors and teachers, formed a society called the Students' Literary and Scientific Society, and it was through the medium of this body, and as the result of discussions conducted with much ability and discretion, that the youthful band of Parsee reformers, led by men so well known at the present day as Dadabhai Naorojee, Nowrojee Furdoonjee and others, established four schools in 1849 for the instruction of girls of their community exclusively. Their Hindoo colleagues were not slow to follow this example. Thus a fair beginning was made, which the perseverance and energy of the Elphinstonians carried almost unaided to a stage of development in some years, when their efforts were recognised and substantially supported by a few leading members of their community. This, in an appreciable degree, gave popular sanction to the cause of female education, and within eight years of the commencement, a Girls' School Association was constituted to conduct and extend the working of these schools. About the same time, in 1857, Government encouraged schoolmasters of vernacular boys' schools to open classes for girls. This, again, gave some impetus to the education of girls of other castes. In 1869, in the whole presidency, there were 209 schools with 9,291 pupils. In the course of another year or two, when the department of public instruction was under its able and energetic director now a member of the Government of Bombay, the Hon. J. B. Peile, it recognised the claims of female education to State aid in a more liberal spirit than had been yet done, with the result of increasing the number of pupils three-fold in a few years. In 1882, there were 343 schools with 26,766 pupils, costing an expenditure of one lac and seventy-eight thousand rupees. Private enterprise, it is gratifying to note, has not been backward in Bombay in stimulating the growth of establishments for the instruction of females. The schools of the association above referred to have had considerable support given them by the Parsees, for whose benefit they are intended. Indeed, they have been managed solely from funds contributed by the community, and the liberality of one of its most respected members, Sorabjee Shapoorjee Bengalee, C.I.E., last year provided a home for the chief among their schools. Another large institution for their exclusive advantage is that which bears the renowned name of Sir Jamsetjee Jejeebhoy, which was founded by that philanthropist. The name of another benefactor, Sir Cowasjee Jehangeer, is associated with the foundation and maintenance of other institutions of a similar character. As I remarked above, the Hindoos have not been slow to imitate the exertions or the benefactions of the Parsees in this direction, while recently, the more enlightened among the Mahomedan section of the inhabitants have shown their appreciation of the benefits that have resulted therefrom by trying to do likewise. The bonds of caste, however, and the trammels of custom have, unfortunately, held the good intentions of these communities in check considerably. Still, all over the Presidency there are female schools of varying degrees of strength and utility; and their free introduction in the territories of neighbouring chiefs is the most undeniable proof of the acceptance, by the native population as a whole, of female education as a necessary adjunct to national progress.

The institutions which I have named here were projected to carry on their work in the vernacular languages. There have been established in later years, however, schools which have conducted instruction in English with much success, and it is evident that all future efforts for the development of higher female

education—in the capital and chief towns, at all events—must proceed on this basis. It may be worth while, therefore, to note here a few facts in connection with the latter. A project of some magnitude was set on foot, in 1863, by Manockjee Cursetjee, a gentleman of distinguished position, which set forth that "to have a school in Bombay for Indian girls to receive English education was a desideratum long felt." Manockjee Cursetjee was an enthusiast, but not a dreamer. He had first practised what he now preferred himself to preach to others; he had successfully educated his own daughters to an extent unknown at that time, and even at this day but rarely approached. The obstacles which had lain in his path, and the unpopularity he had to encounter in this matter, would have daunted a less resolute will than his. By the time he launched his scheme, however, these obstacles had well-nigh disappeared, and he was recognised as the pioneer of female English education. He had gathered round him a number of ardent supporters, with whose moral and material help he founded the Alexandra Girls' English Institution. The marriage of H.R.H. the Prince of Wales had just then taken place, and in honour of that auspicious event, the name of his august consort was, with their gracious permission, given to the school. Started under such promising circumstances, it has heretofore attempted to do its beneficent work. Its career has been chequered and its progress, like that of all kindred establishments throughout the country, slow, owing to various causes, most of them of a general, and a few of a peculiar character. It is, however, located now in a splendid building of its own, and there is no reason why, with the co-operation of the people and of the educational department, it should not become the leading English teaching female school in Bombay Since its establishment, other schools on a similar basis, but on smaller scales, have been established in many parts of the presidency, and these also perform their work with more or less success. And, very recently, another attempt has been made by some enlightened men with renewed vigour to found a large school on a similar basis in Poona. It is pleasing to note that the lead in this project has been taken by an enlightened Hindoo educationist, Rao Bahdoor S. P. Pandit, and other gentlemen of that community. That disinterested friend of India and its people, Sir William Wedderburn, has aided their efforts in a laudable spirit, and made the first donation towards it of the sum of Rs. 10,000, and the Marchioness of Ripon has also encouraged the scheme by her support. They have secured other large endowments, and there is every promise of their proving highly successful. I shall close this brief sketch of education in Bombay, by noting, in conclusion, that there are two normal schools, one in Poona and the other at Ahmedabad, for the training of teachers for elementary classes.

Next in order of time and numbers we come to Bengal and the provinces of Northern India. Here, too, missionaries first inaugurated the movement, and its early narrative would be a repetition of that of Madras and Bombay. It has had to encounter, however, bigger obstacles if possible, its progress has been slower, and the extent of its operations much more restricted. The greater number and influence of the Mahomedan populations in those districts have offered a passive resistance more enduring than that of the inhabitants of other parts of India. And the little that had been done at the outset towards conquering it was neutralised by that disastrous outburst of passions which blackened the history of those districts in 1857. A new beginning had to be made, and with the stimulus of grants-in-aid, the number of schools stood at the low figure of thirty-five, with less than 1,200 pupils. By judicious encouragement, however, the numbers have risen latterly, and the total of schools in 1882 was 1,015, all save twenty-five, however, being for primary instruction only, consisting altogether of 41,349 pupils, and costing not as much as rupees two lacs and a quarter. I shall not trouble you with figures showing the progress hitherto made in the Punjab, the North-West Provinces and Oudh, in Central India, and other smaller districts. They labour under the same difficulties as Bengal, and often to a greater extent, because, generally speaking, Western civilisation has had less influence over the people. There are now a few excellent schools in Calcutta carrying on instruction in English, and the most interesting among them is that which bears the name of its founder, the Hon. Drinkwater Bethune. This gentleman, who was then legal member of council, established in 1847, a girls' school, maintained it for some time at his own expense, supervised its management, and on his death, which took place two years later, left his lands and other property in Calcutta for its endowment in perpetuity. Lady Dalhousie afterwards took much interest in it, and Lord Dalhousie

maintained it, for the next five years, at an annual cost of Rs. 8,000 from his private purse. These disinterested efforts are justly held in grateful remembrance by the people of Bengal, and the name of Bethune is held in esteem and veneration all over India. The school, although its career has not been one of uninterrupted success, has outlived its difficulties, and now holds a high position among other institutions of the kind. It succeeded in passing a student at the entrance examination of the Calcutta University in 1878, and since then it has carried on in its upper classes collegiate instruction. It is all the more gratifying to note, since we had to enter on this part of our subject under a discouraging aspect, that Calcutta is the only town in India which has a college for female students from which they can proceed to University examinations, and which can boast of having turned out already the pioneers of a class destined, we may fairly hope, to become in future powerful for good, the "girl graduate."

At the figures and stages indicated in this necessarily incomplete sketch has arrived the development of female education in different parts of India. It is certainly far from being a glowing aspect of affairs; and when we are told in the result that in the more advanced Presidencies, namely, Madras and Bombay, there is under instruction 1 girl in every 403 and 431 respectively of their female populations, that Bengal follows with 1 in 976, and that in those districts of Hyderabad which have had the benefit of British administration there is but 1 in 3,630, and when were member, too, that there are other large tracts of India whose progress has been thought so insignificant that they had to be left out of reckoning, it will be generally conceded that the future prospects of female instruction are worthy the most serious consideration of all who can feel any interest in the subject. I need hardly say that I approach this part of the subject with utter diffidence, knowing full well, on the one hand, the difficulty of solving those knotty points on which men of large experience and great ability have found themselves puzzled; and being conscious, on the other, of my own incapacity to grapple with that difficulty. All that I shall attempt to do would be to lay before you, in a brief compass, some views which are the outcome of a little acquaintance with and occasional consideration of the subject, and based on circumstances which transpired during a period when I had the privilege to be connected with one of the institutions named above. The views I am afraid will prove to be common-place—vacant chaff well meant for grain. But they will have their use if they but serve to arouse a little interest and attention towards this one of the most important, as it is, perhaps, the most difficult of Indian educational questions, at a time when a long period of trial has lifted it above the initiatory stage; when we have before us an excellent summing up by competent judges, after careful inquiry, and when on the one fundamental point of basing the instruction of the Indian girl on the European system, there is not one dissentient opinion.

The very first question which suggests itself to one in this connection is—If, and how far, Government ought to identify itself with the furtherance of this cause? I I have been a little apprehensive that the passing remark which I made at the commencement, with reference to the active support of Government, might have conveyed the notion that I share the views of those who have an exclusive faith in the efficacy of Government interposition and legislation. I disclaim the credit of entertaining any such belief. It is as fatal to the rise of a nation and the healthy growth of a people as is reliance on *kismet* or fate to individual prosperity; and if there is one country more than another of which this is true, that country is India. "Who would be free, themselves must strike the blow;" and those who chafe under the bonds of caste and of custom, themselves must dash the chains. It is in a different sense that I join in the appeal for Government support; in a sense which pervaded the despatch of 1854, which has the sanction of distinguished officers of Government, and which is adopted by the Education Commission itself. I shall quote just one sentence, which expresses this view in a judicious and masterly manner, from a speech delivered by the Hon. Mr. Justice West, late Vice-Chancellor of the Bombay University, in one of his academical addresses. It runs thus:—

"It is a recognised function of a Government such as ours to foster the infancy of institutions founded on ideas and purposes which find no place in the uncultured mind, to guide their first uncertain steps, and to leave them solely to self-help when they have had time to make their effects practically known."

So long as that time has not arrived—and, in relation to the subject we are considering, it may be said the shaping of that time has but

barely begun—so long Government, through different channels, will have a chief part to play. The results of thirty years of activity evoked by the despatch of 1854, in connection with the education of boys, demand the same zeal now in the interests of the girls, and of the country generally. For this one-sided activity—which, it must be granted, was perfectly justified a generation ago under then existing circumstances—has brought about a dissimilarity in the modes of life and thought of the two sexes which, if allowed to widen or to endure longer, would produce results prejudicial to the interests of the people. An Oriental story has a great bearing on this situation, which you will perhaps permit me to relate here. Once upon a time, the date of which is not fixed, a wise ruler, with the help of his equally wise minister, conducted the administration of the affairs of the kingdom so well that his subjects were perfectly contented, and cherished their king as their father. This was not a pleasing sight unto Ahriman, the spirit of envy and discord. He inflicted on the peaceful kingdom a drought, so that the people had recourse to foul water, which turned their intellects. The king and his minister, who had their supply of water stored to last longer, continued to drink of it, and, with their usual solicitude for the public good, devised means to relieve the prevailing distress. The harder they tried, however, the less were their efforts appreciated, and the more the people refused to co-operate with them, as they disagreed with their policy. A crisis was impending, and the unhappy ruler knew not how to restore order. It became plain, both to the king and the minister, that, if their authority was to be maintained, it was indispensable that they must come to be of one mind with the people at any cost, and the only chance of doing so was to give up the store of pure water and be content to drink of that from which the people scraped their supply. This was done. Their minds underwent the same unsalutary change as those of their subjects, their thoughts ran once more in the same groove, and thus a disaster was tided over. We who have to face a somewhat similar difficulty, are not, however, luckily, driven to the same straits. The pure supply of knowledge is inexhaustible, and it is but just and wise that, if it has changed so far the intellects of one portion of the people of India, the intellects of the corresponding portion should be brought into unison by draughts from the same healthy spring. Thus, we see that, if for no other purpose, only to carry out in spirit and with completeness the fulfilment of that sacred duty which was imposed by the despatch of 1854, it becomes the function of Government to use those measures of encouragement for the education of girls which were employed in the case of boys, and to commence that work by apportioning a substantial annual amount towards that end. At present the grant is entirely disproportionate to the amount required, and an insignificant fraction compared to what is devoted for the purposes of male instruction. Small as the latter is, supposing it is found impracticable to devote a larger share of the State revenues to education, I would even venture to suggest that the time has come when it is rendered desirable that an appreciable part of the available funds should be diverted from boys' schools to assist in the development of those for girls. Generally speaking, people have become alive to the necessity of educating their boys; even the inhabitants of villages distant from centres of activity and enlightenment are impressed with a conviction that their boys must be educated if they are to earn their livelihood. It may be even said of some parts of India that the people are not discriminate enough to train their sons to industrial pursuits which are available to them in the blind race for book learning and examinations. But it is quite contrary with respect to girls. In the very capital cities of the Presidencies, much more in minor towns, and to a greater extent still in the inner districts, people are far from being persuaded that education is indispensable to the training of the female mind. Even those who are led now and then within the charmed circle of liberal thinkers by those few advocates of the cause who are scattered over the land, waver in their conversion after the novelty of the experiment ceases. On the least little pretext they retrace their steps, and I know from personal experience that sometimes pupils themselves become so conscious of the lukewarmness of their parents, that they consider their attendance at a school to be a favour conferred on those who are anxious for its success, which they could at any time withdraw. It would be wearisome to engage your attention to the other causes of the langour, almost the apathy, with which the education of their daughters is regarded by parents. Even the more enlightened among them find their desire in that direction hampered by orthodox members of their families, by the demands of social etiquette fixed by

peculiar customs, and by a hundred other grotesque reasons which require a sound judgment and a strong will to set aside. But let not the effect of these drawbacks be mistaken for opposition on the part of the people, or even for absolute absence of want. I have heard it contended that the unwillingness of the people to pay for the education of their daughters is incontrovertible proof that it is not acceptable to them. I beg leave to differ from that proposition. If a miser is unwilling, or a poor man unable, to pay for a warm coat and goes shivering in the cold, that does not prove that to the miser or the poor man the warm coat would be unacceptable if you choose to give it to him. Perhaps you will agree with me that he will accept it, and be grateful at feeling comfortable under its cover. It would be digressing from our subject to inquire into the causes of the misery or poverty which holds back the Indian parent from sending his daughter to school. But it is too late in the day to contend, on this ground, that the actual want of female education is not created. And once you admit this fact, the question with a Government like ours is not whether to supply it, but how to supply it. In the concluding part of their despatch, the Court of Directors, after suggesting that the measures directed by them would involve a large expenditure, express their conviction in the words of Sir Thomas Munro, that it "will be amply repaid by the improvement of the country; for the general diffusion of knowledge is inseparably followed by more orderly habits, by increasing industry, by a taste for the comforts of life, by exertion to acquire them, and by the growing prosperity of the people" These words are as true, if not more, of male education as of female; the despatch which concludes with them was written equally for the education of both sexes; but the operation which was brought to bear on it was one-sided, as indeed, as I have already said, the conditions under which it had to work then demanded, so that there remains unfulfilled at the present day the more interesting portion of it, the ground for which is as we have seen prepared. It is gratifying, therefore, to note that the very first recommendation on this subject of the Commissioners of 1882 is "That female education be treated as a legitimate charge alike on local, municipal, and provincial funds, and receive special encouragement." This is followed by other excellent recommendations for bringing it into effective operation, and all friends of female education in India would have reason to congratulate themselves if they were put into operation by the executive to the fullest extent, and without delay.

Among the other recommendations I find suggestions regarding three points to which my own brief experience inclines me to attach much importance. These are with reference first, to the training of efficient teachers; second, zenana teaching; third, the qualifying of European or Eurasian young women to carry on instruction in native schools. Each of these subjects is capable of elaborate treatment, and has considerable bearing on the prospects of female education in the immediate future. I can, however, do no more than just make a passing reference to each here.

In the present state of people's thoughts regarding the education of their females, when the whole situation is in a state of transition, it is of paramount importance that the entire machinery of instruction should be as far at least as practicable worked by women. If not the whole teaching work of every school, at least the work of inspection can be without delay entrusted to women; and normal schools should be multiplied and encouraged. Even as it is, the material is at hand; for if early marriage prevents the attendance of girls at schools, early widowhood leaves a considerable number of girls of school-going age at leisure, which cannot be more profitably employed than in adapting themselves to the work of teachers. More than fifteen years ago, when as one result of the benevolent work undertaken by Miss Carpenter, whose name will long remain honourably associated with Indian female education, a normal school was established in Bombay. In a little time, by the offer of a few scholarships, a large number of candidates sought admission; and among these were Hindoo widows, some of whom I believe conduct schools at the present day in an efficient manner. Fifteen years have made a change for the better in the minds of our Hindoo friends, and an invitation to join normal schools would, there can be no doubt, meet with cordial response from them.

The second point, that of zenana teaching, is equally important. It is the thin edge of the wedge. If we have failed hitherto to introduce free air and light into the zenana from without, let us try the weary but more effectual process of creating behind it the want of free air and light, until the purdàh is rent. To a very large extent this work is now performed by missions, as well as the work of education generally.

While every Indian educationist will cheerfully acknowledge his gratitude to these noble missions for their good work, and while he can sympathise with the suggestion of the Commission that religious schools should be equally eligible for aid with non-religious, so far as they produce "any secular results, such as a knowledge of reading and writing," I believe I express the view of most of them who do not insist on considering any particular religion as part of education, that the operation of this measure will require very delicate handling. The least suspicion of bias in favour of religious schools is apt to undo the work of years; and if, owing to the greater efficiency of teaching which these bodies are known to possess, they should, as the result of this provision, appropriate a large amount of grants at the expense of purely secular schools, the impression created thereby would prove seriously detrimental to the cause of female education.

The third subject is the qualifying of European or Eurasian women to teach in native schools. As the English method of teaching grows into favour with the people, teachers of this class will be wanted more and more. The chief item of expense in an English teaching girls' school is the salary of the head mistress, whose services, as a rule, are engaged from this country at a high rate. Well qualified as these ladies are for the work they undertake, their usefulness is considerably marred by their ignorance of the vernacular of the children whom they have to teach; in many cases, for months after they enter upon their work, their communication with their pupils is restricted from this cause. Now, in the chief towns in India, at the very doors of native female schools, there are large establishments for the education of European girls, where they receive instruction on a similar scale to that which obtains in young ladies' institutions here. These children are, in many cases, orphans or of poor parentage, and it is part of the duty which the committees of these schools undertake, to provide work or situations for such when they leave school. It has struck me very often that a large field of usefulness and means of respectable livelihood would be open to them, if they were trained to the work of teaching, and acquired a knowledge of the vernaculars of the country. This opening seems to have escaped the observation of the Boards of European girls' schools in India hitherto, but the arrangement proposed by the Commission is well calculated to draw their attention to it; and it is not too much to say, that if they act upon the hint thus conveyed, long-felt wants on both sides would have a chance of being provided for.

A new project, calculated to give impetus to the cause of female education throughout India, has recently come into existence, namely, the medical training of women. One great difficulty in the way of educationists in India hitherto has been the practical inutility of female instruction; at all events they have been unable to demonstrate to doubtful minds that beyond generally refining the intellect, education has any influence on the happiness or success in life of women. There is even some force in the argument on the other side that the girl who has undergone the primary process of education available to her, if her parents happen to belong to that class which partly in compliment, partly in joke, is called "the reformers," finds herself less useless at home than the girl who is blessed with no schooling whatever. This is a necessary result of the transition stage through which the cause is passing, and none can quarrel with people thus situated if they are not all in a hurry inspired with a love of education for its own sake, but require some substantial practical proof of its power and utility. I remember the sympathy evoked for the cause some years ago from people who had been previously indifferent to it, when a few girls were found to be trained well enough to take charge of inferior classes, and when their trouble was rewarded with substantial little honorariums or scholarships. The fact of the daughter in a poor family contributing, in however slight a degree, to its resources, was bruited among neighbours, and made many converts. In a far greater degree is this new branch of education destined to stimulate the latent desire of the people. You will pardon me if I seem to attach any mercenary importance to this noble movement. I have the greatest faith in the moral and material blessings it is sure to confer on India eventually, and I believe that indirectly it will prove to be a powerful instrument for those who seek to ameliorate the condition of the Indian female. A purely medical mission will have behind the purdah ten times the efficacy of a religious, or even partly religious and partly medical mission. But in the cause of education generally, in inspiring conviction as to its blessings, and arousing a love for its pursuit, each Indian female doctor by the bedside of a patient will be truly a spirit "with something of an angel light." In the ignorant mind too, her practical

ability to effect a cure, and even in those who care for no reward but that which could be measured by money, her example would have the indirect influence of arousing a desire for education. The project has evoked the greatest interest in different parts of India. In Bombay, the munificence of a respected Parsee gentleman, Pestonjee Hormasjee Cama, and in Calcutta that of the distinguished lady, Mahranee Surnomai, has assured it success, and thus given the cause of education generally most timely and much needed help.

Such are a few of the measures pursued, or intended to be pursued in the immediate future, to stimulate the growth of female education. I have been but able to treat of a very few, and I am aware that that treatment is very slender in proportion to their importance. But apart from such measures, the national development of the cause now demands from the nation itself its chief support. The significance of all other help, however valuable and necessary, is, after all, secondary. It is that considerable section of the Indian community which has come into contact with western civilisation, and whose minds have been moulded by European teaching, which has begun to feel sorely the want of education for its womankind, and clamours loudest for its supply—it is that body of men who must lead the way, and demolish all obstacles. Greater activity has of late years prevailed among them, but there is a want of vigour and perseverance which mars its effect. The initiation of the new measures which the Commission has suggested will, however, impose on these men functions for the due discharge of which, well qualified as they are, they will require great courage and consistency. The force of example, too, will be of the utmost use in this matter. Every one of these men is now morally pledged to educate the female members of his family. There have already been laudable instances of the fulfilment of this expectation; and the most striking, as perhaps the most recent, is that of the Mahraja of Bhavnagar, who, having some years ago founded a girls' school in his capital, now sends his own daughters to it. An example like this is worth any amount of preaching. But all this is an uphill work for the natives of India; and they will need all the sympathy and aid which can be extended to them by Englishmen, members of the Government as well as others. Their moral support will go a great way to redeem the toil. We have seen above that the Madras Presidency has been fortunate in a succession of governors and their wives, and of officers entrusted with the direction of public instruction, who have taken a personal and indulgent interest in the work of improving the mental culture of females. If such zeal were manifested all over India, the prospects of female education would be bright indeed. The popular mind, divided as it is by race, religion, and custom, and incapable of judging with discrimination on those delicate matters which are allied with the intellectual growth of the females, is crying for the light, and needs encouragement and guidance. There looms in the distance a golden future; the start has been made, but before arriving at the destination a rough path has to be traversed overshadowed with doubt and with danger. As to the winning of the goal there can be no misgiving however, if those men, both English and Indian, who have at heart her cause would say—

> "But in the shadow will we work, and mould
> The Woman to the fuller day."

DISCUSSION.

Sir RICHARD TEMPLE, Bart., G.C.S.I., said this was not the first time he had the honour of meeting Mr. Bhownaggree, who was a most ardent citizen of Bombay during the whole time he was Governor of that Presidency; and when he had the honour of laying the foundation stone of the splendid new building for the Alexandra Girls School, Mr. Bhownaggree was then the honorary secretary. He was an honoured member of the Parsee community, which had done more practically than all other classes put together in India for education, and this was the more creditable to them, because, although they were influential and wealthy, they were very limited in numbers. Moreover, Mr. Bhownaggree having come to this country on a visit, had the courage to bring with him his sister, in order that she might have the benefit of an English education, and, as he himself said, a good example had a very great influence. It was very pleasant to hear that the first initiation of female education in India was due to Protestant missions, both Church of England and Nonconformist. More might have been said, perhaps, with regard to the greatness of individual talent of native princesses and ladies, for in the history of India there was not a caste, Hindoo or Mohammedan, which had not furnished brilliant examples of female capacity. Time did not admit of reckoning the brilliant achievements of these ladies, in arms, in policy, in the cabinet, and on the field of battle, but there were heroines, Hindoo, Mohammedan, and Mahratta, whose high qualities had been displayed not only in the business of war, but also in the work of peace, and whose efforts had been directed not only to national achievements, but

also to the promotion of charity, benevolence, and good works generally. Of course, under British rule, there were not the opportunities there used to be in revolutionary times for women showing this signal capacity, but still they were doing their utmost in founding benevolent institutions, and in encouraging good works of all kinds. Of these none were more distinguished than the Begum of Bhopal; and of the many acts he was called upon to perform during his Lieutenant-Governorship he looked back upon none with greater satisfaction than when he recommended the Begum for the honour of the Crown; she had not only received the highest title in the ranks of Hindoo nobility, but also had been admitted to the order of the Star of India. But these achievements had not arisen exactly from education; native ladies were not educated in the present, neither he believed were they in the past; and if these talents had been manifested in spite of the want of education, what might be expected in future when they were educated? It was very gratifying to hear that the natives of India themselves were thoroughly aware of the necessity of female education, and he need not add that the Government was equally aware of this necessity. Why then, it might be asked, had not greater efforts been made, and greater success obtained? Things must move gently in India; it was only within the last thirty years that boys had begun to be educated. It took two generations to conquer, to pacify, to settle, and to put the administration of the country in order, and only when that was put on a permanent basis, could attention be devoted to material and moral improvements. Material improvements, of course, had the first place, and when they were to some degree satisfied then moral improvements began, and amongst these education stood in the van. But before you could begin to educate the girls you must educate the boys, and this was more important in India, because in their case there was no prejudice to contend with, whilst with regard to the girls there were the deepest prejudices to encounter. But when the natives began to see how beneficial education was, they would be prepared, in some degree, for the education of girls, and would be prepared to accept the assistance and guidance of the Government. Mr. Bhownaggree had shown what progress had already been made, and had also shown that that was concurrent with the general enlightenment of the country, so that those parts where caste prejudices where most deeply rooted were those were female education had made the least progress. He had suggested that some of the funds devoted to the education of boys should be diverted to the education of girls, but with that view he could hardly agree. No one who was aware of the condition of India could doubt that the education of boys needed all the resources at present devoted to it. If female education were to advance, additional funds must be found, but as population and wealth increased—and wealth did increase rapidly, despite all that was said about the poverty of the people—this difficulty might be met. Amongst the practical measures to be adopted one of the first was the provision of a class of trained mistresses. The account given of the institution of normal schools was most interesting, and he believed there would be no want of native women to come forward for the honoured profession of schoolmistress. Hitherto, such a profession had not been held in great esteem, but the Government and its officers lost no opportunity of impressing on the people that the profession of schoolmistress was not only useful but honourable. Allusion had been made to the fact that there were so many widows destined by the severe rules of their caste to perpetual widowhood, to whom the profession of teaching offered an honourable sphere, and scope for legitimate ambition, and also to the efforts made by various associations who undertook what was called zenana education. Amongst the various phases of this movement, there was none so important as that known as the medical zenana mission. An educated English lady doctor by the bedside of sick Indian ladies was not only a harbinger of mercy, but also an educational agent, whether she intended it or not; and her mere presence had an immediate and almost electrical effect on the minds of the patients whose sufferings she alleviated, or whose lives she saved by skilful medical treatment. Of all the improvements which were now looming in the future of India there was none more grand than that of female education. Many great changes had been introduced in that country, the fruits of which could already be seen—as, for instance, the construction of canals and railways, the improved administration of justice and scientific legislation, and the settlement of landed tenures, the last step of which had been effected by the Bill regarding Bengal tenancy, which had just passed the Viceregal Council. That measure was commenced in his own time, ten years ago, and had only just reached completion. These material and administrative reforms had already begun to show their beneficial results; but there were several social reforms which had yet scarcely come into operation, such as the abolition of child marriage, the re-marriage of widows, and the reduction of marriage expenses. With regard to education, they saw pretty well what would be the result of elementary education, and all that remained was to diffuse it more largely. But even with respect to education, there was one great branch which was now as it were in its earliest growth, of which none could see the ultimate consequences, viz., the spread of scientific instruction and technical knowledge amongst the natives of India. Greater than all these, however, was the question of female education. The results of this no man could foresee; God grant they might be beneficial, of which he had no doubt, for, as Mr. Bhownaggree had said, when men became educated, unless women were educated also, the difference between the two sexes, which was already too great, would become aggravated. Under the influence, however, of female education, that difference

would become less and less, until there was at last that honourable equality between the two sexes which it was the pride of civilised nations like our own to secure. One of the greatest problems of the future would be the effect of education, male and female, cn the religious belief of the country. The spread of knowledge would shake all the faith of the educated classes in the old religions of India, but it would remain to be seen whether those who were thus leaving the ancient ways would be gathered into the fold of Christianity, or go off into Brahmoism. That system had its merits, but was vague, and in some respects unintelligible. He hoped that, through the efforts of Christian missions, and the good example set before the natives of the practical effect of Christianity, they might be led, both by precept and example, into the paths of reasonable and practicable Christianity.

Mr. L. Ashburner said the question of female education in India seemed to be principally a matter of funds, which were not available to extend it very largely. Additional funds meant additional taxation, which was very objectionable. The people, although not so poor as they were frequently represented to be, could not be taxed without putting an additional strain on them, and he should be very sorry to force on female education at the cost of causing discontent.

General Keatinge, V.C., said he disagreed with much that had been said by Sir Richard Temple, though he was not prepared at that moment to enter into a discussion of these points. He believed female education in India simply required fair play and time.

Mr. E. H. Percival had been glad to hear the description given of the progress made so far, but everyone who heard it must regret how extremely small it was. He had looked for suggestions as to extending it very rapidly. At present it was only in very large towns and on a very small scale that it existed at all. The great difficulty in the way of education reaching the millions was that they were scattered about in villages, extremely poor, and to establish a school in every village would cost a great deal of money. It was impossible to start schools in small places for females, there were no funds and no teachers; but he was sorry to find that Mr. Bhownaggree seemed hampered with the old idea of keeping boys and girls separate. In almost all the villages there were schools for boys, and there was no reason at all why the girls should not be taught there. At first there would be a small number, but anyone acquainted with America would know that there was no reason why boys and girls should not sit side by side in school, and it seemed to him that was the only way in which female education could be widely diffused in India. Mr. Bhownaggree recommended Indian widows to turn teachers, but he thought the best thing they could do was to marry again.

Mr. T. H. Thornton said Sir Richard Temple had referred to heroines of India in former days; to their achievements in war, in peace, and in charity; but in intimating that the women of India had never distinguished themselves in the field of literature, he was not quite accurate. Amongst the Afghans, one of the most distinguished writers was a poetess; and again, in the Punjab, there was a volume of poems, known, read, and admired by the learned throughout Hindustan, which was the work of a poetess, the daughter of the Emperor Aurungzeb, the Princess Zeb-un-nissa. To come to more modern times, in Afghanistan there were several ladies of considerable education, and they had certainly a good deal of political influence. In the Punjab he knew there were many well-instructed ladies; one Sikh gentleman of his acquaintance told him that the ladies of his household read eagerly all the literature they could obtain; and another gentleman, a Mahomedan, told him that a lady in his household was a remarkably accurate accountant. Speaking generally, however, there could be no doubt that very great ignorance prevailed amongst the women of India, and it was a matter of the greatest importance that this veil of ignorance should, as soon as possible, be removed. Sir Richard Temple had given very good reasons why education should begin with boys; but, from one point of view, the education of girls was even more important. In educating a man, you educated the individual, by educating a woman, you ultimately educated the household; and by so doing, you laid the foundation of a wonderful power, the power of good home influence. He did not mean that there was not good home influence in Oriental households; nowhere was filial piety more intense, nowhere did brethren dwell in unity more emphatically than in a Hindu family; and he would refer those who would like to know something of life in a Mahomedan zenana to the interesting work of Mrs. Mir Hassan Ali, who shows that it is neither so frivolous, nor so unenlightened, nor so dull as is usually supposed; while those who would take the trouble to read Lal Bohari Dry's delightful book, "Gobinda Sâmentu," would find that the evenings at home in the household of a Hindu peasant were very often more profitable and more moral than the evenings spent in households in England. He might also be permitted to point to a living example of home influence in one of the most promising and enlightened of the younger feudatories of the Empire, the youthful Gaikwar of Baroda, who had had the advantage of having as adoptive mother a lady of singular intelligence, culture, and sympathy—the Maharâni Jamna Bai. Still, it must be admitted that this home influence, though very often good, was for the most part an uninstructed influence, and was not so elevating and elevated as it might become. He was afraid, however, that the desired end would not be realised quite so quickly as Sir Richard Temple thought. He was glad to see the progress that had been made in Madras and Bombay, and

from his own experience in the Punjab he could give a few facts which might prove interesting. There were about 300 girls' schools there, the average attendance being about 10,000, which was not a large number out of a population of 18,000,000, and that represented the result of thirty years work. The amount of education given was not very extensive either; there was one very good school in Lodiana, another in Lahore, and another in Umritsur; but speaking generally, the standard was not high. One great difficulty was the early marriages of girls, another the great difficulty of obtaining efficient teachers, and if Mr. Bhownaggree could induce some highly educated ladies from Bombay to assist in the work in Punjab, their help would be cordially welcomed. He would endorse most fully the remarks made by Sir Richard Temple with regard to the importance, as an educational force, of the extension of women's hospitals and medical knowledge amongst women. Anyone who bore in mind the exclusiveness of the home in India, which did not admit the presence of any male other than a very near relative, and then examined the statistics of death and disease, and saw the enormous mortality amongst young children and women, would at once realise the great necessity for the extension of women's hospitals. Out of nearly a million and a-half patients attending dispensaries in the Punjab, less than one-fifth were women, which showed forcibly the necessity for women's hospitals, not merely female wards. Hospitals were not merely places of healing; they were also temples of conciliation and sympathy between widely different races. The north-west frontier of Indian ran for hundreds of miles beside mountainous ranges full of wild uncivilised tribes, and few forces had been found more potent to develop friendly relations between those tribes and the British Government than the establishment of dispensaries and hospitals all along that border. A very striking instance of this was afforded by an incident which occurred during the late Afghan war, when a town named Tonk was surprised and completely destroyed, the only building remaining intact being the hospital. He believed the extension of women's hospitals, and the civilising influence of well-trained women doctors, would have effects even more potent and far-reaching than those which had followed the establishment of hospitals for males.

Sir Richard Temple desired to add the names of two other learned women to the list given by Mr. Thornton. On the Bombay side there was a poetess, and amongst the Mahrattas of Bengal there was a poetess so distinguished that, when she died in early life, the then Viceroy wrote a letter to her father.

Mr. J. J. Gazdar said none but those personally acquainted with India could possibly realise the great mass of prejudice which had to be overcome with regard to the education both of boys and girls in India. Even at the present day, when education had made such vast strides amongst boys, it was still merely looked upon as a means of earning a livelihood, or obtaining some place or position. If that were the case with regard to male education, how much more difficult was it to extend female education amongst the people. This was a matter which required patience. Every means should be taken to encourage male education, and let the people appreciate the benefits of it for its own sake, and then ultimately female education would naturally follow. He did not say it should not be encouraged, but he did not agree that any portion of the means devoted to male education should be devoted to assist female education. With regard to the assistance which Government could be expected to give, it had hitherto been a difficult and very delicate question for the Government to interfere with, inasmuch as there were religious, social, and caste prejudices to be encountered, and therefore, Government by itself could not undertake to compel the education of females, so as to bring about the result which was so much desired. It might, perhaps, devote funds to this object, and thus give an impetus to the matter, and then leave the natives themselves to fight out the battle, and rely upon themselves; unless they helped themselves, Government could not help them. He believed the opening up of the medical profession would do a great deal, for if the people could be shown that, by educating the females, they would be enabled to study medicine and earn their own livelihood, or contribute to the support of their families, they would take heart of grace, and despite all prejudice, would insist on having their girls educated.

Mr. Martin Wood said, when he was in Bombay, he watched closely these movements in Western India which had been described, the first meeting he attended being the annual meeting in 1865 of the Alexandra College, which was then at a very early stage of its history. He thought Mr. Bhownaggree had hardly given so much prominence as he might have done to the girls' schools in Guzerat, which were established at a very early date, and were evidence of the general desire and readiness to promote girls' education in India. It was stated in the paper that there was scarcely any dissent to the proposition that female education should be based on the English system, and though he was scarcely prepared to dissent from it himself, he should like to refer in connection with it to the paper read, some time ago, by Dr. Leitner on indigenous education, which he thought should be studied side by side with the present one. In that paper Dr. Leitner stated that English education might be advocated as a complement to indigenous education, but not as a substitute for it. He also thought Mr. Bhownaggree was a little too general in reference to the Mohammedans as being responsible for the general discouragement of female education in India. If he referred merely to the invaders, there was no doubt much truth in what he said, but the Mussulmans of the present day were not open to this reproach.

Mr. M. Mull said his profession, as a journalist, had given him the opportunity of closely watching the progress of education in general, and he was much surprised to hear Mr. Percival, and also Mr. Bhownagree, speak with such despair of the progress of female education in India. The movement had only just begun, and what were twenty years in such a case. What had been done in England with regard to female education. It was only within the last twenty years that it had taken any strides. He thought the progress made in India was most gratifying. With regard to Hindoo female life, there was great ignorance in England, and at a meeting to promote the zenana movement, he had had to remonstrate against the terms that were used. When Sir Richard Temple was Lieutenant-Governor of Bengal, he read a paper on the Mahabharâta, when Dr. Mouatt, in the course of the discussion, referred to the domestic virtues of the Hindoos as delineated in some of the finest passages of that great poem, and as illustrated in the daily lives of his audience, in which matters he said they were not behind the most advanced nations, and had nothing to learn from them.

The Chairman said he could claim no special knowledge of this subject, but having been for many years connected with public education in England, when Mr. Bhownaggree informed him that he might be of service to the cause by taking the chair, he felt it impossible to refuse. He had listened with deep interest to the paper and discussion, and was disposed to agree rather with Mr. Bhownaggree than with Mr. Gazdar in thinking that female education in India did require aid from the State. He would only make one remark, and that with great diffidence in the presence of many who knew India very well. When outsiders heard of female education in India they were apt to think only of zenana education; now to his mind the word zenana raised at once the thought of that fatal system of polygamy, and the sequestration and seclusion of women which prevailed amongst the higher classes in India as in Turkey, and he felt inclined to say, do not make the zenana of too much consequence; do not in what you do for education fix your attention too much upon it, treat it rather as a thing that will pass away, throw yourselves into instituting schools, and in founding education as much as you can upon the people, those laborious classes amongst whom for obvious reasons polygamy is unknown, and to whose advance and example we must look for the extirpation of polygamy both in Turkey and in India. He agreed with Mr. Bhownaggree that it was of great importance that the vernacular languages should be studied by European women who were to deal with education in India, and it was also of great importance, the founder of Alexandra College also thought, that those whose education was conducted in those Indian schools should study the English language and literature. With what success this could be done they had had an eminent example that evening, having witnessed what a perfect command Mr. Bhownaggree possessed of the English language, both in writing and speaking. He concluded by proposing a hearty vote of thanks to him for the interesting and instructive paper he had read.

The resolution having been carried,

Mr. Bhownaggree said he was glad to find there were very few points of difference which he need reply to. All were agreed on the one fundamental question, that there was a great want of female education in India at present. Sir Richard Temple, in his very able speech, while bearing testimony to the correctness of most of his views, had, to some extent, disagreed with one suggestion of his—that the funds available for the education of boys should, in part, be diverted to the education of girls; but this was not a proposition which he made absolutely, but only conditionally, on Government finding its resources so restricted that no more could be spared in the cause of education generally, in which case he thought it was apparent that some means should be found to bridge over this great gulf between the two sexes. He was not alone in this view, and he might mention that in the course of a conversation which he had, five years ago, with a very able officer in the Education Department of Bombay, that gentleman told him that from his experience he, in a great measure, agreed with him. With regard to Mr. Percival's suggestion, that girls should be encouraged to attend the boys' schools, he, to a large extent, agreed with him, and believed that was the only way out of the difficulty; but, at the same time, the prejudices of the people must be respected, and he was afraid many Indian parents would be averse to their girls attending a mixed school just as they arrived at the age when people in enlightened countries thought the education of a child ought to begin. He thanked Mr. Thornton for bringing out prominently one point on which he had made a passing reference in the paper, viz., the enlightenment of the Mohammedan people; and Mr. Martin Wood had also introduced an important qualification, with which he quite agreed. He was glad to say that the Mohammedan gentlemen of the present day were generally of opinion that education for girls was desirable, if not necessary. His remarks as to their discouragement of female education were intended to apply to the period when the Mohammedan supremacy was established. Even at that time, and before and since then, there had been rare instances of learned women among them; and contact with enlightened communities taught them a lesson which they had not been slow to profit by. He could not altogether agree with Mr. Gazdar's suggestion to leave the education of the girls in abeyance, and simply promote the education of boys, and that the education of girls should not be compulsorily established at the expense of the boys.

What he contended for was, that the education of girls did not need compulsion; there was the want of it felt, and the question was, how to supply it? India was a very large country, and what was true of one part might not be true of another; still, generally speaking, the want of female education was very perceptible, and he believed all would agree that that being so, something should be done to supply it. With regard to Mr. Martin Wood's remarks, disputing the advisability of imparting instruction in English, he might not, perhaps, have correctly expressed his views, but he certainly did not desire that education should proceed altogether in English. What he suggested was that with the increasing influence of the British administration the system of education, whether imparted in the vernacular or in English, must proceed on the English method. There was something like the Oriental method still known in some parts of India, but it was rapidly going out of fashion. Having briefly noticed the points raised in the discussion, Mr. Bhownaggree said he was very much gratified to find that on a matter which could scarcely appeal personally to an English audience, such an influential gathering had been assembled, and he felt that the natives of India could not be too grateful for the interest shown here in a question which affected the future of India to such a great degree. In conclusion, he would ask the audience to join with him in thanking the distinguished gentleman under whose chairmanship they were met. The cause of Indian female education would profit not a little by the interest personally shown in it by one of those men "whose thoughts enrich the blood of the world," and Mr. Matthew Arnold's presence there that night would no doubt be of great service in future to the policy which he had endeavoured to advocate.

FOREIGN & COLONIAL SECTION.

Tuesday, March 17, 1885; HYDE CLARK in the chair.

The paper read was "The Congo and the Conference, in reference to Commercial Geography," by Commander CAMERON, R.N.

The paper and discussion will be printed in the next number of the *Journal*.

FIFTEENTH ORDINARY MEETING.

Wednesday, March 18, 1885; Lord ALFRED S. CHURCHILL, Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Ellington, Edward Bayzand, Palace-chambers, Bridge-street, S.W.
Fosbery, William Thomas Exham, The Castle-park, Warwick.
Vaughan, J. I., Woodleigh, East Dulwich-grove, S.E.
Watson, Charles, 5, Paradise-row, Stockton-on-Tees.

The following candidates were balloted for and duly elected members of the Society:—

Allin, Samuel Sealy, 52, Woodstock-road, Bedford-park, Chiswick.
Angus, John, 47, Lime-street, E.C.
Collum, Rev. Hugh Robert, The Vicarage, Leigh, Tonbridge, and Junior Athenæum Club, W.
Hutchinson, C. C., 28, Windsor-road, Forest-gate, E.
Norman, Simeon, London-road, Burgess-hill, Sussex.
Russell, John, 16, Marloes-road, Kensington, W.
Sanderson, Thomas Crisp, 31, Hatcham-park-road, New Cross, S.E.
Schloesser, Frank, 10, Sutherland-avenue, W.
Stone, Thomas William, 17, Davisville-road, Shepherd's-bush, W.

The paper read was—

THE RIVERS POLLUTION BILL.

By J. W. WILLIS-BUND.

The Society of Arts has recognised so often, and on so many different occasions, the extreme importance of pure water, that any remarks on the importance of preventing the pollution of streams would be impertinent. The only question is, what are the best steps to take to secure the purity of our rivers? It will at once be said, "Abstain from polluting them;" but the best way to enforce this abstention is far from an easy matter. As I am in some respects responsible for the latest effort in this direction, having drafted the Bill now before Parliament, I am desirous of stating clearly what that Bill seeks to do, and how far it alters the existing law. It is the more important to do this, as considerable misapprehension exists as to what are the aims of the Bill, and its provisions have been somewhat severely spoken of by some of the persons interested in the question. It will be desirable to see first what the existing law on the subject really is.

The pollution of rivers has always been deemed by law to be a nuisance, and the usual remedies given by the law to prevent a nuisance apply. They are two—either an action to recover damages, or proceedings for an injunction to restrain the acts that constitute the nuisance. It has been settled, by a

series of decisions, that every riparian owner is entitled to have the water come to him undiminished in quantity, and undeteriorated in quality, by the acts of the riparian owners above him. If, in either respect, this right is infringed, he has his remedy. But this remedy is, in some cases, worse than the disease; only those who have engaged in litigation as to rivers and their pollution can form any idea as to the cost of trying to prevent it. Frequently they are so heavy as to be prohibitive. A contest in which scientific witnesses are engaged, lasting over a week, involves the expenditure of not merely hundreds but thousands; and few riparian owners are rich enough, or if rich enough, feel inclined, to incur the cost. Hence pollutions have been allowed to increase to such an extent that it seems that what is called in the decisions the natural right to have pure water no longer exists, but that the present normal right is to have impure water.

What is required, and has been so for years, is some cheap, speedy, and effective way of dealing with pollutions; that is what we have not yet got, but hope to get by the present Bill. The evils of certain pollutions have been long recognised by the Legislature. So far back as 1847, very stringent penalties were imposed by the Gasworks Clause Act as to pollution arising from gas workings or substances used in making gas.* In 1861,† a clause imposing a heavy penalty on persons allowing liquid or solid matter to pass into a salmon river, to such an extent as to poison or kill fish, became law. So far as it goes, the clause is valuable, but its application is very limited, it applies only to salmon rivers, and to obtain a conviction the prosecutor must prove that fish were actually killed, a thing it is very difficult if not impossible to do in many cases.

The report of the Rivers Pollution Commission brought out very clearly the real state of the rivers of the country, and a Bill, founded on the recommendation in that report, was, at the instance of the Fisheries Preservation Association, introduced into the House of Lords. It failed to become law, but it was the forerunner of the Act of 1876, that is now the chief statute on the subject.

That Act is open to grave objections, and it is to remedy these objections that the present Bill is framed. To mention some, there is first the great delay that must ensue before any proceedings can be taken under it. It is necessary to give an offender two months' written notice of the intention to take proceedings, and it may happen that a case cannot be heard for two months more. A case of pollution arising from the refuse of a flannel manufactory came under my notice; it was determined to take proceedings under the Act; the County-court in that district was held once every two months. Written notice was given to the offender in June; in August, when the two months were up, the County-court had just been held, and would not meet again until October, so four months elapsed before the case could possibly be heard. An adjournment was applied for by the polluters in October, and granted: fortunately, before the next court they went into liquidation, but meanwhile they had had five months' uninterrupted pollution. Cases might be put when a much longer time would be consumed before the case could be even heard. In a subject where promptitude is everything, the fact of being by the Act unable to proceed for two months, is of itself sufficient to condemn the Act.

Another great objection to the Act is the classification of pollutions into solid and liquid, making one rule as to one, and one as to the other. As has been pointed out in the discussions in this Society, there is no reason whatever for the distinction. A pollution is none the less grievous because it arises from solid matter, and a liquid pollution will be as destructive as any other. It is only making difficulties, and giving rise to legal complications, to subdivide pollutions in this way. The object of the law is to restrain pollutions, from whatever source they arise, whether they are solid or liquid, and the same rules should apply to each. But under the 1876 Act, this is not so. To restrain pollutions arising from solids, other than from mines, anyone can take proceedings. Some liquid pollutions only sanitary authorities can restrain, and they must get the consent of the Local Government Board before they can institute proceedings; pollutions that arise from solid matter in suspension cannot be proceeded against under the Act, at all for while pollution by solids are dealt with by Section 2, and by liquids under Section 4, the interpretation clause (20) states that solid matter is not to include particles of matter in suspension in water. If therefore, the solid matter is only in suspension when it is discharged into the river—and by far the greater quantity of solids that pollute a stream are in that state—no offence is com-

* 10 Vic., c. 15.

† 24 and 25 Vic., c. 109, sec. 5.

mitted. This division of pollutions into liquids and solids, and the further subdivision of solids into those that arise from mines, and those that arise from other sources, and the next subdivision those that merely contain matter in suspension, and those that contain such matter or other solids, give rise to great and wholly unnecessary difficulties in enforcing the law. One of the earliest cases under the Act was a proceeding to restrain the discharge of large quantities of sawdust into a stream, but it was held, and perhaps rightly, that sawdust, being solid matter in suspension, did not come within the Act.

But if the Act is ineffectual as to solids, it is worse as to the next division—sewage. Why sewage pollution was made a distinct division it is hard to say. The Local Government Board were empowered to grant a sanitary authority time to adopt means to purify the sewage before the Act is enforced; and were empowered to suspend the operation of the law as to sewage, from time to time, indefinitely. The result of the clause is, that in the seven years the Act has been in operation, practically nothing has been done; the sanitary authorities have not cared to incur expense, if they could avoid it. Landowners have not cared to take proceedings against sanitary authorities, which they know will prove abortive, for as soon as an injunction is obtained, the sanitary authorities apply to the Local Government Board, and say they are going to take "the best practicable and available means;" time is granted, and the pollution runs on. One instance will show the way the clause works. In the year 1878, proceedings were taken against the Corporation of Hereford, and an injunction obtained restraining them from discharging their sewage into the River Wye. The operation of the order has ever since been suspended from time to time, to enable the corporation to do something, and the result has been they have done nothing.

The Act not only gives to the Local Government Board power to suspend the operation of the clause, it also gives the County-court judge a power to suspend the operation of the order indefinitely if he pleases, or he may even rescind it entirely. If any one takes the trouble to read the return published last year of the prosecutions under the Act, they will find that out of fifty-two cases in which proceedings have been instituted, in ten cases these suspensory powers were employed. Can it be wondered that persons hesitate to enforce the law, when the only result is to get an order which is adjourned from time to time and never enforced?

As to liquid pollutions the case is worse; unless the liquid proceeds from a factory, manufacturing process, or mine, it is not within the Act; if it does, and if a person wants proceedings instituted he must take the following steps. He must get the sanitary authority to apply to the Local Government Board for leave to take proceedings. If they refuse to do so, as most likely they will, not wishing to spend money, or not to prosecute a large ratepayer who is very likely a member of the body, then the person aggrieved can apply to the Local Government Board, the Board hold an inquiry, and they determine if the sanitary authority ought or ought not to take proceedings. If the Board think the sanitary authority should proceed, they direct them to do so. But if the authority differ from the Local Government Board, and think they ought not, then the Board will have to compel them to do so; this all means considerable delay, and quite likely an action to determine if proceedings shall or shall not be taken; on its being determined that proceedings shall be taken, then two months' notice of the intention to take proceedings must be given to each individual polluter proceeded against. On this any individual polluter can go to the sanitary authority and object to any proceedings being taken against him, and they may then determine if they will take proceedings or not, and if they determine not, there is an end of the matter. Thus the whole matter is in their power, and even if the Local Government Board and the High Court of Justice are both of opinion that such proceedings should be taken, the sanitary authority may say they shall not. A more extraordinary bit of legislation it is impossible to imagine. The sanitary authorities are, as a rule, composed of the polluters of the district, yet the Legislature allows them to say, even if the highest Court in the kingdom holds they ought to take proceedings, we will not do so. Those of you who have had practical experience of sanitary authorities will agree that to make them the supreme authority on questions of pollution was the best possible way of securing the effectual pollution of our rivers. The clause is so startling, I give it *verbatim;* it is the last part of the sixth section of the Act.

"Any person . . . against whom proceedings are proposed to be taken. . . shall, notwithstanding any consent of the Local Government Board, be at liberty

to object before the sanitary authority to such proceedings being taken, and such authority shall, if required in writing by that person, afford him an opportunity of being heard against such proceedings being taken, so far as relates to his own works or manufacturing processes. The sanitary authority shall, thereupon, allow such person to be heard by himself, agents, and witnesses, and after inquiry, such authority shall determine, having regard to all the considerations to which the Local Government Board are, by this section, directed to have regard whether such proceedings, as aforesaid, shall or shall not be taken."

It must have been at a very early hour in the morning that such a clause as this was allowed to pass into law.

Even this does not complete the protection the Act gives to polluters. The 13th section empowers inspectors of the Local Government Board to grant certificates to the effect that the polluter is using the best practicable and available means of rendering the pollution harmless under the circumstances of the case, and the certificate is for two years a conclusive answer to all proceedings that may be taken against him, and it may even, at the expiration of the two years, be renewed.

There are various other provisions in the Act in favour of pollution, such as the right to compel sanitary authorities to receive liquids from manufactories into sewers, thereby exempting the polluter from all liability as to what he discharges into the sewer. But enough has been stated to show that the Act of 1876, instead of giving facilities to check the pollution of rivers, really gave every facility to persons not only to continue pollutions undisturbed but also to increase them under legislative protection.

The Bill proposes to do away with all this. The 2nd clause absolutely prohibits pollution, whether solid or liquid, and from the date of the passing of the Bill any pollution would be illegal, and immediate proceedings could be taken to restrain it. Whether the matter is in suspension or in solution, whether it is solid or liquid, it is illegal. The only exception would be drains from private houses that did not discharge sewage or injurious solid matter, and ordinary land drains. It does but little more than the 1876 Act proposed to do, but it leaves out all the provisions and exceptions that whittled away that Act until it became a legal sewer for the discharge of pollution into rivers. On the hearing of a case, under this section of the Bill, the only question will be, has the alleged discharge into the river taken place, and if so, is it injurious? If it is, an offence has been committed. I venture to submit that nothing short of this will ever really restore the purity of our rivers.

The fifth clause retains the County-court as the authority to adjudicate upon offences against the Bill. There is much to be said both for and against this. It would not do to allow the local magistrates—who are very often, in boroughs, the great polluters—to carry out the Act, because, as they are *ex-officio* members of sanitary authorities, they would have already, in many cases, determined the question; and these cases often give rise to points that require a trained lawyer to decide. But yet the County-court is by no means a satisfactory tribunal. In most country places it only sits once a month, sometimes only once in two months, and a County-court judge would hesitate, if he had the power, to grant an injunction *ex parte*, even if any one could be found to undertake as to damages. It is this that is the real difficulty of the question—to find a cheap tribunal that will act speedily. The High Court is very effective, and very speedy, but it is not cheap; the County-court may be cheap —it by no means follows that it is—but it is neither effective nor speedy. The third clause introduces an important alteration of the law; it retains the power of the Court to give time before enforcing its order; but it does not allow the sanction by the Court of any plan for purification that does not bring the water within certain standards of purity mentioned in the Bill. These standards of purity are those proposed by the Rivers Pollution Commission. They have been attacked vigorously by various persons representing the manufacturing interests. It is said that, in some cases, they are too severe, in others, not severe enough; that if they were carried into effect, then the water of every stream would be purer and better than the drinking water now supplied to London; and that they would cause a number of manufactories to be closed. I am not able to give any opinion upon them; they are what the River Pollution Commission said should be the standards, and the question as to how far they are right or wrong rests with them. All I want to point out is, that they do not apply to any pollution in the first instance; they only come into force when the Court has said that the pollution is illegal and must be stopped, and the polluter applies for the sanction of the Court to a particular mode of purification. The Bill, instead of saying the best practicable and available means shall be

employed, gives this security—that no means shall be employed that do not reduce the pollution to such a state as the Commissioners say is the least that can be properly required. Taken in this view, it will be seen that there is but little hardship in their adoption. It would be one thing to say that nothing should be discharged into a river that infringes those standards; it is a very different thing to say, as the Bill does, that a person who is bound by an order of a Court to cease from an illegal act, shall only be allowed to continue that act upon certain terms. The continuance at all is an act of grace, and, as an act of grace, such conditions should be attached to it as should prevent it working harm to others. A very important modification of the standards that has the approval of the promoter of the Bill has recently been proposed by Dr. Frankland. He proposes to divide the water into two classes—that used for drinking supply, that not so used. For drinking purposes the standards would remain as contained in the Bill, with the omission of one relating to colour. As to other waters, the following modified standard would be adopted:—

"Standards of Purity," for other than water used for drinking supply, shall mean—

(*a*.) Any liquid which has not been subjected to perfect rest in subsidence ponds of sufficient size for a period of least six hours.

(*b*.) Any liquid containing, in solution, more than two parts by weight of organic carbon, or one part by weight of organic nitrogen, in 100,000 parts by weight.

(*c*.) Any liquid which, after acidification with sulphuric acid, contains, in 100,000 parts by weight, more than two parts by weight of free chlorine.

(*d*.) Any liquid which contains, in 100,000 parts by weight, more than two parts by weight of sulphur, in the condition either of sulphuretted hydrogen, or of a soluble sulphuret.

(*e*.) Any liquid possessing an acidity greater than that which is produced by adding ten parts by weight of real muriatic acid to 1,000 parts by weight of distilled water.

(*f*.) Any liquid possessing an alkalinity greater than that produced by adding two parts by weight of dry caustic soda to 1,000 parts by weight of distilled water.

(*g*.) Any liquid exhibiting a film of petroleum or hydrocarbon oil upon its surface, or containing, in suspension, in 100,000 parts, more than ·05 part of such oil.

The rest of the section practically corresponds with the tenth section of the existing Act; and the fourth section of the Bill, as to the removal of a case into the High Court, corresponds with the eleventh of the Act.

The fifth makes an important change in the law, and is the vital section of the Bill. Hitherto the sanitary authorities have had the option of taking proceedings or not, as they pleased; there has been nothing to compel them to do so. The object of the fifth section is to make it incumbent on the sanitary authorities to take proceedings. If a complaint is made to them, and they do not, they could then be compelled to do so. If they take proceedings and do not prosecute them with due diligence, any person interested may apply for the conduct of the proceedings; and carry them on at the expense of the sanitary authority. The Bill follows the lines of the Act, making the sanitary authority, in the first instance, the person to take proceedings; but having regard to the way in which the sanitary authorities have carried out their duties under the Act, it goes on to provide for a mode to compel them to do their duty, by depriving them of that discretion that the experience of the last few years has shown to be synonymous with doing nothing. If the law is not carried out now, it will be the fault of those who are injured, for the clause enables them to compel the sanitary authorities to enforce the law, and, if they delay, to enforce it at the expense of the authorities. But this, wide as it is, would not be sufficient. As the sanitary authorities are often the great polluters, it is also necessary to provide for their prosecution, for it could hardly be expected they would prosecute themselves. The Bill goes on to say that any person aggrieved may institute proceedings, but to prevent manufacturers being unduly harrassed, it provides that if a private person commences proceedings he may be ordered to give security for costs.

The sixth clause gives the Local Government Board a power of sanctioning an application to the Court for the enlargement of time to carry out any purification works. By the third clause, the Court, in the first instance, fixes the time in which the work is to be done. No power is given to the Court of itself to enlarge the term. This power has led to such abuses as in the Hereford case, that the value of any Bill that perpetuated it would be materially decreased. Cases, however, may happen where the works are being carried out, and the term ought to be enlarged to enable the work to be completed. To meet the case, the sixth section is framed. If the polluter can convince the Local Government Board that an extension of time should be

given him, they may consent to an application by him for an enlargement of the time. Without this consent the time will not be enlarged, as there is no jurisdiction to do it, with the consent it can only be enlarged for six months It is to be hoped that by this or some similar means, the scandal of orders being obtained but never enforced will be obviated. The clause also provides for an alteration of the mode of purification mentioned in the order restraining the pollution, the Court may, if it please, specify in the order the means that are to be used to prevent the pollution. It will be, if one may venture to say so, a very foolish Court that makes such an order, but still it may do so, and it may happen that some more efficient or less costly means of preventing the pollution may be discovered. Of course, if such was the case, it would be only right that such means should be employed, and if the polluter can convince the Local Government Board as to there being better means of preventing the pollution, and they will assent to his applying to the Court to adopt those means, the Court may give leave to use them, with the qualification that the standards of purity are not infringed. I am by no means clear that this clause should stand in the Bill. It seems to me that the Court should never tie its hands, by making an order that a person should adopt any particular means of preventing pollution, or tell the polluter how he is to prevent it The order should be in a well known Chancery form, that the defendant do not pollute the river. Let the defendant use any means he pleases, and change and alter those means from time to time, so long as he obeys the order, but do not incumber the order by introducing in it matter that may or may not work injustice.

Another reason why I should like to see the clause omitted is this, that the Bill would then confer no new power or any central authority, create no new authority, provide for no inspectors, in fact would be simply what it should be, "A Bill to amend the proceedings in County-courts in cases of pollution of streams."

The seventh clause saves existing rights and remedies; those who can afford it can still go to the High Court; the Bill simply gives additional powers, but in no way interferes with existing ones.

The eighth clause contains, in one sense, some new law. It imposes a penalty on all persons who have opened new channels and drains into rivers since 1876. The Act of 1876 made the opening of such drains and channels illegal, but provided no penalty; this clause supplies the defect, and imposes a penalty.

The interpretation clauses, and the clauses extending the operation of the Act to Scotland and Ireland complete the Bill.

It will thus be seen that the Bill does not really extend the existing law. What it does is to sweep away all the provisions, exceptions, and restrictions that made the 1876 Act unworkable. It states plainly what the law is, and how it is to be carried out. The main points are:—

Anyone who pollutes a river by any of the modes mentioned in section 2 may be restrained by the County-court. The only question the Court will have to try will be—is there a pollution, and is it from one of the sources mentioned? If so, then an offence has been committed, and an order must be made.

In the first place, a sanitary authority, on its own instance, or on the instance of any person aggrieved, shall take proceedings. If it does not, or if, when the proceedings are begun, they are not carried on with due diligence, then the person aggrieved may apply to carry on the proceedings at the expense of the authority.

Any person aggrieved may take proceedings himself, but to prevent merely vexatious proceedings, he must find security for costs.

If these provisions pass into law, then if our rivers still remain polluted, the fault will not be that of the law, but of those who suffer from the pollution. They will only have to thank themselves if the law is not enforced, and the rivers and streams of the country purified.

As I stated at first, the Bill has been strongly opposed by various interested parties. I agree that there are several of its provisions open to great question, and they ought to be fully discussed, and I hope to hear them discussed to-night; but if the standards of purity were struck out, and the Bill only consisted of the two points, definition of pollutions, and the power to anyone to take proceedings, it would do much that was required. Once it is recognised by all interested in our rivers that there is a law that prohibits pollution that can and will be enforced, the polluters will see that it must be obeyed, and will obey it. The existing state of things arises only from the fact that the polluters know that it is difficult to enforce the law, and they reckon on the chance that it will not be enforced in their case, and do nothing to stop the pollution. The odds are so greatly in their favour, that it is worth while to run the risk.

To stop a pollution costs money; persons will not lay out money until they are obliged; and the Act of 1876 does not oblige them to do so—that is the whole of the case; the question is not as to the evil of polluted rivers, on this every one is agreed, but whether the law for putting an end to that evil shall be made effective, or remain as it is, an ineffective piece of legislation. All the Bill purports to do is to make efficient an inefficient statute, and so it should receive the hearty support of all reformers, whether sanitary or legislative.

DISCUSSION.

The following letter from Prof. Henry Robinson, addressed to Lord Alfred Churchill, Chairman of the meeting, was read by the Secretary:—

7, Westminster-chambers,
London, S.W., 18th March, 1885.

My Lord,—I regret my inability to be present at the Society of Arts meeting this evening. I send you a print of my paper (and the discussion on it), on "River Pollution," at the Parkes Museum, recently. My views are fully set forth in that paper, but I should like to add to what I say in regard to the standards, that I am of opinion they should be altogether omitted from the Bill, both in the form in which they now stand in the Bill, and also in the modified form proposed by Dr. Frankland. I should be glad if this expression of my opinion could be conveyed to the meeting.

I am, my Lord,
Your faithful servant,
Henry Robinson.

Mr. G. W. Hastings, M.P., said no object could be more important in respect to the health of the community than that of preserving our natural supplies of water pure. Everywhere throughout the country search was being made for pure water, and at the same time we allowed the pure water, which was supplied us by nature, to be polluted by the wilful acts of mankind. He had been much struck with what had been going on in his own county of Worcester for many years past. It possessed one of the noblest rivers in the kingdom, the Severn, which illustrated very forcibly the evils which this Bill was intended to remove. Beginning almost at its source in Wales, it was polluted by lead mines and other works, and as you came lower down every town built upon it used it as a common drain into which to pour its sewage. Welshpool, and several other towns in Wales, Shrewsbury, Bewdley, Stourport, and even Worcester, which ought to be proud of the noble river on which it stood, all poured their sewage into it; and the latter town had a Bill now before Parliament for extending its boundaries, which contained an express provision enabling it to send the sewage of these new districts into the river. Upton-on-Severn, a few miles down, did the same. A few years ago Cheltenham was thinking of establishing a water supply from the Severn, and it was then shown before a Parliamentary Committee that the Severn water, by the time it reached Tewkesbury, was utterly unfit for human consumption. Nevertheless, the town of Tewkesbury did so use it, and there was no wonder that a good deal of disease prevailed there. This was a specimen of what was going on all over the country, and the question was whether the Legislature ought not at once to step in and prevent it. He had nothing to say against the present Act, which had done a certain amount of good; its chief imperfection was that it was to such a large degree permissive. This evil could not be efficiently dealt with in that way; it was too far-reaching in its consequences to allow of local authorities having the option whether they would pollute the rivers or not. The great aim of the present Bill was to make it compulsory on local authorities to see that rivers were not polluted. He was somewhat amused, not long since, at a discussion in the Worcester Town Council on this very subject. One speaker said he hoped this Bill would pass, because then they would be obliged to prevent their sewage going into the river, and until they were obliged they would never do it. That was really the position of things in many places. Town Councils and other bodies knew perfectly well the mischief they were doing, but until some power was brought to bear upon them by the Legislature, they would never stir. One reason, no doubt, was the expense, and the fear of causing unpopularity with the ratepayers; and another was that often some of the most influential members of the local bodies were themselves the polluters of rivers, and the fear of offending them and the influence they exerted, prevented local authorities taking the proper steps. It was necessary, therefore, for Parliament to step in, and say once for all that these bodies had a duty to perform, and that they must do it without further delay. One clause in the Bill seemed to arouse considerable opposition, and might perhaps be further considered—that fixing the standards of purity. More than one manufacturer in the north had already told him they should oppose the Bill to the uttermost if this clause were retained, because it would be destructive to their business. He would, however, advise those interested in the matter to read the evidence given before the House of Lords' Committee before the passing of the present Act, and especially to a remarkable piece of evidence given by Sir Lyon Playfair, who was himself interested in some large works situated on a Scotch river. He said he had not yet discovered the means of effectually preventing the pollution of the river from the matter they were obliged to pour into it; but he was quite sure that, if an Act were passed rendering such purification compulsory, he should in a short time find the means of rendering it innocuous. Very lately, Sir Lyon Playfair told him that since the introduction of this Bill, which had his most hearty

support, he had discovered the means of putting a stop to this pollution. This showed that if a little compulsion were brought to bear, manufacturers would soon discover the means of preventing pollution without injury to the processes they were carrying on. No one desired to interfere with the manufacturing industries of the country, but he was convinced that a great deal of the mischief was done quite unnecessarily, and that when the Act was passed, manufacturers would soon find the means of complying with it. He was quite prepared to consent to any modification in those standards which could be shown to be necessary. At present he thought the standards were somewhat heroic in their nature, and his idea was that more good would be done by passing a measure to which it would be easy for every one to conform, than by passing one which might be better in itself, but which would raise opposition on the part of those who thought they were being hardly dealt with. Professor Robinson, as they had heard, was in favour of omitting the standards altogether, but he should be sorry to see that done. It was very useful to have some standard of purity in a Parliamentary enactment, and as time went on that standard might be raised, when it was found not to be attended with the difficulties many imagined. The real pith of the Act, however, lay in its compulsory character. This had already awakened a considerable amount of opposition, but he believed it would be evercome; for he believed the bulk of the House of Commons were so impressed with the necessity of taking some further steps, that any selfish or interested opposition would be borne down. At all events he could assure the Society that any efforts he could make, in this or any ensuing session, to pass the measure into law, should not be wanting.

Mr. C. N. Cresswell remarked that no one was more competent than Mr. Willis-Bund to draft or expound such a Bill as that now under consideration. In his position as Chairman of the Severn Fisheries Commissioners he must have had long and painful experience of the necessity for such a Bill, and though he (Mr. Cresswell) did not agree with all its provisions, the points of difference were slight, and when the Bill went into committee he had no doubt they would be much attenuated, if not altogether removed. It was admitted on all hands that our rivers were polluted to such a frightful extent, that it was absolutely necessary for something to be done to prevent their total destruction for all useful purposes; and also that the Act of 1876 was altogether ineffectual for the purpose intended. This was admitted by some of the most enlightened manufacturers themselves, not only in London, but in the more important manufacturing centres. If it were necessary in 1875 and 1876 that some measure should be passed to prevent this great public mischief, *a fortiori*, now, when it was found that that Act was inefficient, was it necessary to improve it. One great advantage of the present Act was that it, for the first time, recognised it to be an offence to pollute a river; that was a great moral gain which had not been sufficiently recognised. In his opinion, to convince the Legislature, composed to a great extent of manufacturing capitalists, that it was an offence, a misdemeanour, to pollute a river, was almost as great a step as when Moses laid down the law—"Thou shalt not steal." Everything in the history of the constitution and of legislation showed that we must proceed by gradual and tentative steps, but when once you educated public opinion up to the pitch of admitting that a thing was wrong, you were on the high road to getting it abolished. There were many merits in this Bill, the chief one being its simplicity; it described in unequivocal, intelligible terms the offence it intended to prohibit, and was simple in its definitions; whereas, in the present Act, the definitions encumbered, embarrassed, and almost nullified it. It also simplified and cheapened the procedure. One cardinal merit again was in what it omitted to say. The Act of 1876 exempted the Metropolitan Board from the operation of the Act, and also the Thames and Lea Conservancy Boards, for what reason no one had been able to explain, though the late Sir Henry Cole suggested that the enormity of the offence committed by the metropolis was such that the Legislature did not dare to cope with it. In the present Bill there was no exemption, and that which had become the most flagrant reproach to civilisation—the pollution of the River Thames, would be no longer possible under it. One of the vices of the Bill, in his view, was the fifth clause, which rendered it necessary to call in the aid of the sanitary authority, and that in such a way as to produce a feeling of irritation, because it enabled a person to say, "If you do not act, I will make you;" or, "I will take proceedings in your name, and you shall pay the expenses." Never, in his experience, had legislation made such an enormous stride as that, and he feared the result would be only to create ill-feeling on the part of a body which would have almost unlimited powers of embarrassing and hindering proceedings. He should prefer to see that clause expunged, and doubted if the House of Commons would pass it. Again, in most cases, the sanitary authority itself was the principal delinquent, and there was something foreign to English ideas in making a criminal his own prosecutor. He should prefer to see what they heard so much about in 1879-80, the constitution of an authority in a much higher and more independent position—a County or District Board, having for one of its main objects the conservancy of rivers. A Bill for this purpose had been introduced, but had been shelved to make way for more pressing matters. But if a stringent Bill like this were passed, it seemed to him equally necessary to complete the work, to create a body which could and would, without fear or favour, see that Act carried into effect. If this Clause 5 were retained, all the moral and social obstacles to the operation of the Act which had been encountered

during the last nine years would be rendered more bitter and resolute than before; but the establishment of County Boards having charge both of the quantity and quality of the rivers, would remove the difficulty. In 1881, under the influence of a panic caused by the prevailing floods, this question was very much discussed, both in that room, where he proposed a resolution on the subject, and at the Social Science Association; and two or three Bills were brought before Parliament; but in 1882 the floods diminished, in 1883 they altogether ceased, and since then nothing had been heard of Rivers' Conservancy Boards. But it was just as necessary to have such Boards to preserve and store water as to prevent floods, and the question seemed to him as important now as ever it was. The most important point of all, however, was that of the standards, but he understood that the promoters of the Bill were willing to amend it if necessary, so as to make it generally acceptable, especially to manufacturers. It was a curious circumstance that these standards, or tests of maximum impurity, were inserted for the protection of the manufacturers, though they had been slow to appreciate the benefit conferred on them. They were inserted because it was not considered fair to impose on manufacturers, many of whom had enjoyed the prescriptive rights of pollution from time immemorial, without defining with some degree of accuracy the amount of their responsibility. For his own part he should much prefer to see the clause expunged altogether, but manufacturers would soon regret it. So long as these tests existed, they could protect themselves, but once make each river its own standard, and beginning at the head of that river, and carrying your operations down towards the estuary so as to gradually purify the river, the standard would be constantly rising, and manufacturers would soon regret not having accepted the standards proposed. These were objected to by many important bodies throughout the country as being too lenient; he knew no place whose opinions were entitled to more respect than Glasgow, and he found that two very eminent men there, Professor Mills and Dr. Wallace, objected to these standards because they were ridiculously lenient. No one would dream of pouring into a stream any effluent containing as much acidity or alkalinity as these standards would permit; in fact, the Glasgow people were almost unanimous that in that respect it would be most dangerous to adopt the standards proposed. Sir Lyon Playfair said they were the minimum concession which could be made, and in fact there was not a single river in the country at the present time which would not comply with them. His advice to manufacturers was to take them and be only too satisfied, for if they were altered, it would be to make them more stringent. He had read the discussions which had taken place before the different sections of the Society of Chemical Industry in London, Birmingham, Liverpool, Manchester, Glasgow, and Newcastle, and the general effect was, that instead of being received with general execration as he had anticipated, Glasgow had absolutely welcomed the Bill; and if manufacturers would only listen to men like Dr. Wallace, they would find that they had everything to hope and nothing to fear.

Dr. BARTLETT said he would address himself mainly to the question of standards of purity or pollution, whichever they might be called. In his own view, it was quite necessary for anything like compulsion that some standard should be laid down. Without doing so, the Act must be practically permissive, and every County-court judge would have to decide on his own standard of what constituted pollution, and not feeling himself confident to do so, could not give an immediate judgment, which was a matter of the greatest importance. Having been in communication with many members of the House of Commons on this subject, he found in many cases their views were adverse to his own, their contention being that if the standards were insisted on, there would be a great risk of losing a valuable Bill. He did not agree with that; it would be better to lose the Bill this session and bring it on again than to pass an ineffective measure. Dr. Frankland had at first taken a different view to himself, but after some discussion they were now agreed that it would be better to have the most lenient standards of purity than none at all, and these could be amended from time to time, and made more effective as science advanced. If there were nothing to go upon, there would still be the same conflict of scientific evidence as at present, and the decision in one case would be of no value as bearing upon another. Dr. Frankland and himself were now in accord with regard to the elasticity of the standards. For twenty-five years he had mainly represented the manufacturing interests, while Dr. Frankland was supposed to represent ideal purity, and if they were in accord, as they now were, the Bill ought to be accepted. The present standards, which were those of the Royal Commission, in fact Dr. Frankland's standards, were either too high or too low; too high for rivers whose waters were not used for drinking purposes, and too low as regards the ideal purity of potable water. After a considerable amount of discussion they had now, practically, agreed that rivers from which no considerable quantity of water was drawn for domestic purposes, might have lenient standards with regard to the effluents poured into them, speaking generally, from two to five times less pure than mentioned in the Bill; a broad line of distinction being drawn between rivers from which water supply was habitually taken, and those which might be termed merely refuse streams; but in the latter case provision was made that nothing deleterious to health, either from offensive smells, or subsident matter on the side of the stream, which might cause fever, should be allowed. In making this arrangement, he thought they had hit upon the just medium, but they did not claim to have reached perfection, and from th

first it had been arranged that when the Bill went into committee, evidence should be received and every consideration given to all interests likely to be affected. Mr. Willis-Bund used the expression that under this Bill no pollution of a river could exist, but if these elastic standards were accepted, no hard and fast line would be drawn; and for the present he believed that would be best. He could say from his own experience that if the lower standards agreed upon by Dr. Frankland and himself were inserted in committee, every manufacturer throughout the country would be obliged to confess that he could not only easily comply with the regulations, but that he would benefit by the Bill, because with other people, acting on the same principles, the pollution of the stream would be prevented. He might mention, that in the case referred to, of the works with which Sir Lyon Playfair was connected, not only was the pollution of the stream prevented, but a profit was made by the operation, and that would be the case in the majority of cases.

Major LAMOROCK FLOWER said he could point out the great advantage which would be derived under the new Bill, by the abolition of exceptional legislation. For the last fourteen years he had been endeavouring to carry out the Lea Conservancy Act, so as to prevent the pollution of the river, and had seen the evils of exemption. Luton had a clause exempting it from the operation of the Act, and was allowed to discharge its sewage, if clarified by a certain chemical process; fortunately, it did not avail itself of the exemption, but passed its sewage through land. Hertford, again, had a special clause, and was one of the chief polluters of the Lea. Tottenham had for years availed itself of its special clause, and did as little as the ratepayers allowed it to do. At West Ham they had another special clause, and said that so long as London sent its sewage into the Thames, so long would they send theirs into the Lea. By passing this Bill all these special clauses would be got rid of, and he or his successors would be able to make the river pure. He was at first opposed to standards of purity, but recently, in consequence of the discussions between Dr. Frankland and Dr. Bartlett, he thought they had arrived at a model standard, which he trusted would be embodied in the Bill. There should be one standard for a river above where water was taken, and another applicable to the lower reaches of the river, provided always that the latter was made equal to the requirements of public health. Mr. Cresswell had brought forward a proposition he had heard from him before—that some higher authority than the local sanitary bodies was required to carry out this Act, and in that he quite agreed with him. Tact went a great deal further than legal proceedings; and though he had always endeavoured to avoid prosecutions, he had been able by tact alone to stop an enormous amount of pollution, and he should like to see the same opportunities which he had extended over the whole kingdom.

Mr. GRANTHAM said he had not had much experience in preventing pollution, his principal work having been in the prevention of floods. He gave evidence before the Lords Committee in 1877, from his own experience in connection with the Land Drainage Act, and he quite agreed with what had been said, and he hoped something would be done by the energetic persons who had the matter in hand to secure the entire prevention of river pollution.

Mr. HENRY NOEL, as one of the Lea Conservators, had listened to the discussion with much interest. Mr. Hastings said the beauty of the Bill was its simplicity; it simply enacted that a river should not be polluted, and if the carrying it out were as simple as the enactment that would be very nice, but he feared it was only a delusion to suppose that if a river were polluted you would only have to go to a County-court and get the evil remedied at once. Hertford was a town of about 7,000 inhabitants, the sewage of which was led for nearly a mile down dark filthy ditch, which no one passing it could fail to recognise by his eyes and nose as pollution of the foulest kind; it debouched at the end of a lock where there was no stream; and from time to time hundreds of tons of stinking black mud had to be removed from it. They imagined that was pollution, but upon the highest scientific evidence that could be procured they were informed they were totally mistaken, that there was no pollution; and it cost them £6,000 to arrive at that result. He should like to see a provision inserted that wherever practicable, where there was high land available, sewage should be filtered through it before it was discharged into a river. Only the previous day he was at Bishop's Stortford, where the sewage, without any chemical treatment whatever, was filtered through land, the solid portion being first intercepted, and the liquid effluent, after filtration ran into the river in a constant stream the size of his arm, and no difference could be detected in the river above or below, either in the colour of the water or the vegetation. He put his arm as far as he could up the pipe and pulled out a handful of slimy growth upon it, and could not detect the slightest unpleasan smell. This showed the advantage of filtration on suitable land, not in low lying, water-logged places, as some sewage farms were. He wished Mr. Hastings every success in passing this Bill through Parliament.

The CHAIRMAN, in proposing a vote of thanks to Mr. Willis-Bund, said he had not studied the Bill, and therefore could not criticise it, but there could be no doubt that the absolute necessity for further legislation had been abundantly shown, and he quite agreed that it should be compulsory. Permissive legislation was sometimes useful in educating public opinion, but that object having been attained by the Act of 1876, it was now necessary to go further. He believed one great reason for the dilatori-

ness of local authorities hitherto had been the prevalent idea that some profit ought to be made out of sewage, and the authorities had been holding back in order to see how this could be done. Such attempts generally ended in failure, and the sooner it was recognised that sewage must be got rid of, without any regard to profit, the better.

Mr. W. H. DENHAM seconded the resolution. He not think there should be any standards of purity beyond nature's own standard. He did not think manufacturers had anything to fear if the Bill were properly carried out.

Dr. BARTLETT said he had not the least idea what was meant by nature's standard of purity.

The resolution having been carried unanimously,

Mr. WILLIS-BUND, in reply, said he considered one of the great merits of this Bill was that it created no new authority, but utilised those already existing. He had the honour of being connected with several Boards, and he had the greatest horror of them. Having a Board for everything was one of the great curses of the country. A Board required an establishment and consequent expenses, and, of course, increased taxation. If they could get rid of half the Boards instead of creating new ones it would be far better. But looking at the great cost which proceedings of this kind involved, considering what Mr. Noel had said with regard to the Hertford case, and to other cases of the kind, he thought there ought to be some protection for a manufacturer against being needlessly harrassed by a pauper. He knew one case where a pauper took proceedings against a sanitary authority for a nuisance, and carried it to a Conrt of Appeal, and although the authority eventually succeeded, it cost them over £2,000. There might be a sanitary Mrs. Weldon who might commence proceedings, and carry them even to the House of Lords, and, therefore, some protection ought to be given by requiring a plaintiff to give security for costs. With regard to what Mr. Noel had said about the appearance of the effluent water, he might say that he knew a case where the water looked very beautiful and clear, and it was said there could be nothing the matter with it, but it came from an old mine, and, when analysed, it was found to contain a large quantity of arsenic in solution. Appearances, therefore, could not always be relied upon. He was in favour of standards. Unless there were some standard, there would be great danger of doing injustice unintentionally to manufacturers and others, and, therefore, whatever the standards might be, on which he offered no opinion, he thought there ought to be some test. It should not be left to the individual opinion of every County-court Judge. In conclusion, he said the society which was promoting this Bill was going to hold a meeting at the Mansion-house on the 25th inst., when the presence of any supporters of the movement would be welcome.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The arrangements for the lighting of the buildings and the grounds are being proceeded with. Some 18,000 incandescent lamps will take the place of the coloured oil lamps for the illumination of the grounds and the roof of the large conservatory. Within the building there are to be 464 arc and 5,530 incandescent lamps, or more than double the number used last year.

The Lighting Committee is composed of Sir Frederick Bramwell, the Marquis of Hamilton, Sir Frederick Abel, Mr. W. H. Preece, Professor Dewar, Colonel Sir Francis Bolton (who again undertakes the direction of the illumination of the fountains), and Colonel Festing.

Twenty-one systems of electric lighting will be shown, equal to the illumination of 533,000 candles. The arrangement of the systems are—Eastern Arcade and Western Avenue, Varley lights by Goulard and Gibbs; Dining-rooms (on the site of the dairies), Bernstein lights by Paterson and Cooper; Chinese Restaurant, Gulcher and Woodhouse and Rawson lights; Old London, Mackie lamps, arranged to produce a moonlight effect; Prince of Wales's Pavilion, Swan lamps; Water Pavilion, glow lights by Goulden and Trotter; South Galleries Middl Court, Swan lamps, 1,080 in number, equalling 1,600 candles, by Messrs. Siemens; North Court, Victoria incandescent lamps, by the Anglo-American Brush Electric Light Corporation; South Court, lights by the Edison-Swan Company; Grill-room, lights by Clark and Chapman; Aquarium, glow lamps by the Gulcher Company; East Gallery, arc lights, by Thompson, Houston, and Co.; South Central Gallery, Jablochkoff arc lights; in different parts of the Exhibition, Pilsen lights, lamps by Paterson and Cooper; Cordner, Allen, and Co.; Clark, Muirhead, and Co. (Carden and Werner patterns); Sennett lamps, and lights by Clark and Bowman. There are also six Hochhausen lamps of 3,000 candle-power each, for the masthead; twelve Siemens lamps of the same strength for the fountains, and sixteen Andrewes lights of 800 candle-power for the electric light shed.

The steam power which is to keep in motion the generators will again be provided by Messrs. Davey, Paxman, and Co., of Colchester. To the ten steam boilers and five powerful steam-engines in use for the lighting of the Health Exhibition they will add eight large locomotive boilers. These new boilers, which are all made of steel of the first quality, are constructed with the most modern improvements. Each will contain 610 square feet of heating surface, and it is computed that, with easy firing, these eight boilers will evaporate 36,000 lbs. of water into steam

per hour. With the whole set of eighteen boilers it is calculated that 110,000 lbs. of water per hour can be made into steam of 100 lbs. pressure per square inch. For the illumination of the grounds Messrs. Siemens will employ three engines, capable of about 1,000 horse-power work, by Messrs. Goodfellow and Matthews, of Manchester, supplied by Babcock and Wilcock boilers.

ACCIDENTAL EXPLOSIONS PRODUCED BY NON-EXPLOSIVE LIQUIDS.

A lecture on this subject was delivered at the Royal Institution, on Friday, 13th inst., by Sir Frederick Abel, C.B., D.C.L., F.R.S.

The lecturer stated that his attention had of late been specially directed to accidents connected with the transport, storage, and use of volatile inflammable liquids employed as solvents, and as illuminating agents.

Particulars having been given of a large number of explosions resulting from the application of flame to vessels which had contained volatile coal-tar or petroleum products or spirituous liquids, the lecturer referred to cases in which the vapour of volatile hydrocarbons had travelled considerable distances from the vessels containing the liquids, and, becoming ignited, had conveyed flame to such liquids. Instances were also adduced of explosions resulting from the accidental escape of benzoline and similar products into sewers and wells. The violently explosive nature of a mixture of hydrocarbon vapour and air was illustrated by reference to several cases wherein ships conveying petroleum spirit or benzoline had been destroyed, with loss of life, by the ignition of such a mixture which had accumulated in the hold of the vessel. The difference between petroleum spirit and petroleum oil, in regard to liability to the production of such explosive atmosphere, was then pointed out, and the lecturer stated that experience had shown that even should a cargo of the ordinary petroleum oil of commerce become ignited, by lightning for instance, the fire might be extinguished, and the cargo saved, by securely battening down the hatches, and thus excluding the air.

It was shown that the explosion which primarily caused the loss of the *Doterel*, by leading to the ignition of the gunpowder in the magazine, as well as similar explosions, fortunately attended with less serious results, which occurred on H.M. ships *Triumph* and *Cockatrice*, and the Pacific Steam Navigation Company's steamer *Coquimbo*, resulted from the escape and volatilisation of a paint "driers," known as Zerotine Siccative, which was among the ship's stores. In regard to the *Doterel* case, the lecturer stated that at first the existence of this liquid on board was not suspected, and the information collected by the Royal Commission on Explosions in Coal-laden Ships, of which the lecturer was a member, led to the belief that the loss of the vessel might have been due to the accumulation of gas in the coal bunkers, and ignition of the explosive atmosphere thus produced. A committee, of which the lecturer was a member, was accordingly appointed by the Admiralty to consider and report upon the question of the possible formation of explosive gas-mixture in the coal bunkers of H.M. ships, and subsequently the same committee made an experimental investigation of the effects liable to result from the escape of so-called Zerotine Siccative.

The burning of the *Goliath* training ship, near Gravesend, in 1875, was next referred to as an illustration of the conditions under which mineral oils, not easily volatilised, may become dangerous; the fire which destroyed the vessel being shown to have arisen from the dropping of a lamp which, there was reason to believe, had become overheated from the unusually high flashing point, and consequent inferior burning quality of the mineral oil used.

The development of the employment of liquid hydrocarbons as illuminating agents then received attention, the growth of the shale oil industry, founded in 1850 by Mr. James Young; of the petroleum trade of the United States, dating from the sinking of the Drake Well in 1859; and of the comparatively recent petroleum trade of Southern Russia, with which Messrs. Nobel Brothers are so prominently associated, being traced. The concurrent evolution of the many excellent mineral oil lamps of the present day, from the primitive appliances available in the early days of the trade, was illustrated by a representative collection of lamps.

A careful investigation of the circumstances attending numerous accidents, together with a critical examination of the construction of various lamps, and the results of many experiments had, up to the present time, led the lecturer and Mr. Redwood to arrive at several definite conclusions with respect to the immediate causes of lamp accidents, and to certain circumstances which tend to favour the production of such explosions.

If a partially filled lamp were carried or rapidly moved, a mixture of oil vapour and air might be caused to escape from the lamp in close vicinity to the flame, and, by becoming ignited, might determine the explosion of the mixture existing in the reservoir. This escape might occur through the burner itself, if the wick did not fit the holder properly, or through openings which exist in some lamps in the metal work close to the burner, of sufficient size to allow flame to pass them readily. A sudden cooling of the lamp by its exposure to a draught, or by being blown upon—as, for instance, in adopting the common practice of blowing down the chimney to extinguish the flame—might give rise to an in-rush of air, and the flame might be at the same time drawn or forced into the reservoir. The sudden cooling of the glass, if it had become heated by the burning of the lamp, might also cause it to crack if it were not well annealed, and the

fracture, which might allow oil to escape, might convey the impression that an explosion had taken place. If the flashing point of the oil were somewhere about 73° F. (the minimum fixed by law), vapour would be given off comparatively freely, but the mixture of vapour and air would be but feebly explosive, while if the flashing point were high, vapour would be less readily and copiously produced, but the vapour mixture would be more violently explosive. If the quantity of oil in the reservoir were but small, and the air-space large, an explosion would obviously exert greater violence than if these conditions were reversed. If the wick were lowered very much, or if for some other reason the flame were burning very low, the lamp would be liable to become much heated, and the tendency to the production of an explosion would be increased. Oils of high flashing point were more liable to cause heating of the lamp in consequence of the higher temperature developed by the combustion and the comparative slowness with which a heavy oil was conveyed by the wick to the flame. It therefore followed that safety in the use of mineral oil lamps was not to be secured simply by the employment of oils of very high flashing point (or low volatility), and that the use of very heavy oils might even give rise to dangers which were small, if not entirely absent, with oils of comparatively low flashing point. The character of the wick very materially affected not only the burning quality of the lamp, but also its safety. A loosely-plaited wick of long staple cotton would draw up the oil to the flame regularly and freely, while, if the wick were very tightly plaited and made of short staple cotton, it would be of inferior capillary power, the oil would be less copiously drawn up, and undue charring of the wick —with considerable heating of the lamp—might ensue. If the wick were damp when taken into use, or if the oil contained moisture, the capillary action of the wick would be impaired; and long-continued use of the wick would be liable to result in its becoming choked with impurities, held in suspension in the oil strained through it. Many lamps were so designed as to facilitate the production of explosion, openings or channels being provided, through which the flame might pass into the oil reservoir.

The adoption of the following simple suggestions would materially reduce, if not remove, the risk of accident which attends the use of petroleum and paraffin oil:—

1. It is desirable that the reservoir of the lamp should be of metal. It should have no opening or feeding place in the reservoir, nor should there be any opening or channel of communication to the reservoir at or near the burner, unless protected by wire gauze of 21 meshes to the square inch, or packed with wire, or unless it is of a diameter not exceeding 0·04 inch.

2, The wick should be of soft texture, and loosely plaited; it should fill the entire space of the wick holder, but should not be so broad as to be compressed within the latter, and it should always be thoroughly dried before the fire when required for use. The fresh wick should be but little longer than is required to reach to the bottom of the reservoir, and should never be immersed to a less depth than about one-third the total depth of the reservoir.

3. The reservoir of the lamp should always be almost filled before use.

4. If it is desired to lower the flame of the lamp for a time, this should be carefully done, so as not to lower it beneath the metal work more than is absolutely necessary; but it should be borne in mind that even then the combustion of the oil will be imperfect, and that vapour of unconsumed petroleum will escape, and render the lamp very unpleasant in a room.

5. When the lamp is to be extinguished, and is not provided with an extinguishing apparatus (of which many excellent forms are now supplied to lamps) the flame should be lowered until there is only a flicker; the mouth should then be brought to a level with the top of the chimney, and a sharp puff of breath should be projected across the opening. The lamp should remain on a firm support when it is being extinguished.

BOTANIC GARDENS OF THE NILGIRIS

Mr. Lawson's report on the progress and condition of the Government botanical gardens and parks, Nilgiris, for 1883-84, like most of those which treat of public parks and plantations in various parts of India and in our Colonial possessions, deals, firstly, of the ordinary routine work of the Ootacamund garden, which is interesting, of course, only to those who have a personal knowledge of the gardens. Coming to the scientific aspect, Mr. Lawson states that the herbarium now contains some four thousand species, the most part of which are correctly named. The value of a good herbarium and museum to every botanical centre cannot be over-estimated, for by their aid not only are the people taught the importance and uses of the vegetable kingdom, but they are enabled to identify plants that must of necessity find their way to every botanical centre for accurate naming, many of which may, perchance, prove to be of the utmost commercial importance. Referring to the museum, Mr. Lawson says a small collection of woods, fruits, seeds, and other vegetable products of botanical or economic interest to those living in the Nilgiri plateau has been brought together. This collection is at present unarranged for want of space, and is consequently of no practical value, but it is recommended that provision be made for the public exhibition of these specimens. It is further recommended that while Madras ought to possess the first museum in the Presidency, other smaller museums, containing typical collections of objects of interest in their own neighbourhood, should be established in various centres over the country. Mr. Lawson

says, "If Government should sanction a museum at Ootacamund, I would advise that it should contain such objects only as would be of interest to those living on the Nilgiri plateau and the Wynaad; I would like also to see the museum take in all the chief branches of natural science—botany, zoology, geology, mineralogy, and ethnology. I am sure that such a museum of local products would be of service to those who are engaged in commercial, agricultural, or other pursuits in this district, and I do not think that it would cost very much to set one on foot."

Under the head of "Short notices of some of the most interesting plants which have been grown in the gardens during the past year," some well-known and valuable economic plants are referred to. Of the Liberian coffee it is stated that the plant grows vigorously and fruits abundantly wherever it has been introduced, but that there is very little demand for it. Owing to the smaller portion of pulp which coats the seed, it is more difficult to clean than that of *C. Arabica*. Regarding ipecacuanha, it is satisfactory to know that the stock of plants, which at the end of 1883 consisted of 170, has been increased to 630, all of which are in a healthy condition, and there will in future be no difficulty in increasing the number indefinitely. Mr. Lawson thinks that the production of ipecacuanha will never become a part of forestry proper, but he feels sure that in the moister climates of the west coast and the Wynaad it may be cultivated profitably in gardens. Of the now well-known cuprea bark (*Remijia Purdieana*), so rich in quinine, 250 seedlings are stated to have been raised from a packet sent from Kew. A few seeds also of the quillaia bark tree (*Quillaia saponaria*) have been raised and are doing well. The value of this tree, which is a native of Chili, lies in the fact that a large quantity of saponaceous matter is found in the bark, so that it is largely used in its native country as a substitute for soap, and is also much used on the continent for similar purposes. Amongst edible or food plants, the arracacha (*Arracacia esculento*) has been raised from tubers received from Kew. The plant belongs to the natural order Umbelliferæ, which inhabits the more mountainous tracts of the northern parts of South America. The roots are divided into several fleshy lobes, each of which resembles the root of a carrot, and are said to have a flavour between a chestnut and a parsnip.

The following india-rubber yielding plants are reported as growing with more or less success:—*Castilloa elastica*, yielding Central American rubber; of this, thirty-one plants were distributed during the year, and the stock in the propagating house, at the time the report was written, consisted of eighteen healthy plants. Of the *Hevea brasiliensis*, or para-rubber, Mr. Lawson had only one specimen, and this was planted out at Barliyár, and during the last year grew 18 feet. *Manihot glaziovii*, the ceara-rubber, is said to grow freely whenever it has been tried. At Barliyár, there are many trees over 30 feet in height, with a diameter, at 1 foot above the ground, of 18 inches. The trees fruit abundantly, and produce good seed, but there is no demand for it on the part of the public. Of the *Landolphia florida*, or West African rubber plant, Mr. Lawson reports as follows:—"I am sorry to say that all the Government plants of this rubber-yielding climber are dead; but am glad in being able to report that the species is doing well at Nilambur, where it is being grown under the auspices of Mr. T. S. Ferguson. A second un-named species which was sent from the Agri-Horticultural-gardens, Madras, is doing well."

Of the now well-known fodder plant, *Symphytum asperrimum*, abundance of the better varieties is to be had in the neighbourhood of Ootacamund. Mr. Lawson expresses surprise that there should be any prejudice against its use. Grown in deep soil in the more humid places, such as the sides of streams, it would produce a crop of most nutritious food for cattle all through the dry season.

A considerable amount of attention has of late years been given to a reddish yellow dye, known as "waras," which was at one time thought to be the produce of a species of *Mallotus*, and closely allied to the *Kamala* (*Mallotus philippinensis*) The substance in question consists of the small glands which cover the fruits of species of *Flemingia*, herbaceous plants belonging to the natural order Leguminoseæ. Mr. Lawson says, "There are several species of *Flemingia* growing on the Nilgiris and their slopes, all of which produce the red glands, the richest of all being probably *F. vestita*, var. *neilgheriensis*. From inquiries which I have made, I cannot learn that anything like the preparation of 'waras' is manufactured in Southern India, though I am informed by the coolies working on the Government cinchona estate at Naduvatam, that the plant is used in some places of the Wynaad for dyeing clothes." Indian waras appears to be derived chiefly from *Flemingia Grahamiana*.

THE PRODUCTS AND RESOURCES OF CURACAO.

Consul Barnes states, in his last report on the resources and industries of Curaçao, that it is one of the islands of the Caribbean Sea longest known to a portion of the commercial world, and is yet one of the least known portions of the civilised world. The length of the island from north-west to south-east is 36 miles, its breadth about 8 miles, and its area about 164 square miles. It lies 46 miles north of Coro, a coast city of Venezuela, in latitude 12° N., and longitude 69° W. Near it lie Bonaire, Aruba, and Little Curaçao, and these, with the St. Eustatius, Saba, and the south part of St. Martin, among the Windward Islands, comprise the Dutch West India possessions. Fruits and vegetables are grown in considerable quantities in the island, and originally there were large quantities of braziletto and other

dye woods, but nearly all has been exported. In the shallow valleys, where some brackish water percolates the subsoil, several varieties of fruit trees flourish, and produce excellent fruit. In some parts of the low ground a dam of masonry is often to be found, confining any moving product of a rainfall for weeks for use in irrigation. The most abundant of the fruits grown in Curaçao are the mango; the nispero or sapadilla; the mamon, a small fruit of pleasant acid taste; the guanabana or soursop; the lechosa, the tree grape which grows, as the name indicates, upon a tree, the berries ripening singly and falling one by one; the cashew; and the cactus or Indian fig. Of the various banana fruits, the supply is chiefly from the mainland, and the demand is large and constant. The large varieties are used extensively as table food, taking the place of other farinaceous food to a considerable extent, especially among the poor; when sliced lengthwise and fried in olive oil or butter, or boiled, they are considered as a great delicacy. The principal fruit, however, which has made the name of Curaçao known to the world is the orange grown there, the *Citrus vulgaris*, called there the *Naranja cajera*. Both the tree and the fruit are small, and the latter is of a deep green colour. No other tree receives such care and cultivation on the island as this, and the fruit itself is only used with syrup to make a sweetmeat or *dulce*, as it is termed. The skins are harvested for a constant market. At that stage of development of the fruit when the rind contains a maximum of oil, the fruit is picked, and peeled in quarters, and the quarters are dried and pressed and packed in half-barrels for export. The total product of the orchards in orange rind is shipped to Amsterdam, and the price paid varies from three shillings to eight shillings per Dutch pound, a tenth more than the pound avoirdupois. By distillation the oil is extracted from the skin or peel, and used to flavour the celebrated liqueur "Curaçao." As regards live stock, the animals on the several islands are very few, owing to the scarcity of forage and water. There is no breeding of horses, no mares being kept, and any stock that may be required is imported from the coast, where horses may be purchased at from £6 to £20 each. They are used only for carriages and for riding, and though usually of small size, they are hardy and serviceable. Cows are seldom kept for milking purposes, as they produce very little. Very few sheep are reared upon the island, their wool being of an inferior kind, and the supply not abundant, and, owing to the coarseness and scarcity of forage, their meat is very inferior. Curaçao and the sister islands have two productive sources greater than all others that have been mentioned, but which are not yet extensively utilised; these are the opportunities for producing salt in great quantities and very easily, and the other is the deposit of asphalt found there. The greatest deposit is in the island of Curaçao, and is of extraordinary richness and compactness. At the south-east of the island there is a headland of about 600 feet in height and steep upon all sides, and it is composed of rich phosphate worth millions of pounds. Shipments of the best qualities, of from 40 to 80 per cent. purity, have been made to British markets, and during the last half of 1883 large shipments were made under the British flag. The Colonial Government receives about 16s. a ton royalty on shipments from this deposit, and from the royalties upon Araba and Curaçao phosphates the receipts, with the more limited ones from other sources, more than pay the expenses of Colonial Government, leaving a balance to the credit of the Home Government. Curaçao is not rich in mines, but gold mining is carried on to a limited extent. Copper ore is found on the northern end of Curaçao, but in very small quantities. Rich copper is found upon the mainland, about 40 miles in the interior, and the mines are a source of great profit to the owners. Consul Barnes says that the past and present importance of Curaçao does not lie in the abundance or importance of its productions, but may be accounted for by the following facts:—From Puerto Cabello, in Venezuela, to the mouth of the River Magdalena, in the United States of Colombia, a distance of over 1,000 miles of coast line, there is no harbour or good roadstead where vessels large enough for long voyages can enter, with the exception of the harbour of Maracaibo, on the lake of that name, from which, however, vessels drawing more than 10 feet of water are excluded by the bar at the mouth of the lake. Curaçao lies about 45 miles out from this line of harbourless coast opposite Venezuela and the city of Coro forming her capital, a place as populous as any of her coast cities. Curaçao has one of the best and safest harbours of the world, and is practically a free trade city and country, the receipts from imports merely paying the expenses of guarding a legitimate trade.

INDUSTRIES OF TEXAS.

H.M. Consul at Galveston says that the State of Texas continues to advance with rapid strides, and quotes as a proof of his statement the assessed value of taxable property, which for 1883 is placed at \$462,000,000, as against \$311,000,000 in 1880; while in the year 1870 it was only \$170,000,000. It has recently been estimated that the total value of the produce of Texas, for the year 1883, was \$107,000,000, and this shows an increase of \$22,000,000 on the estimate of the previous twelve months. The population of the State is rapidly increasing, as shown from the census of 1880, when the total number amounted to 1,591,000, or very nearly double that of 1870. The State takes no steps to attract immigration, but numbers find their way there from the States of Tennesse, Mississippi, Georgia, and Arkansas; many also come from Ohio, Indiana, and Illinois. There are also large arrivals of immigrants from Germany and Bohemia, who come to

join their relatives and friends, and there are towns in Texas where German is the language used to the almost entire exclusion of English. Consul Bridgett says that Texas is a good country for men with a small capital, accustomed to farming, and also for those who have learnt a trade, such as carpenters, blacksmiths, stonemasons, and that it is not uncommon for men who have been doing good work in the last-named occupation to receive 25s. a day. The tendency is towards small farms, and the large plantations are mostly in the south. The majority of the farms are not cultivated by the owners, but are occupied under the share system, which is most in favour, and appears to bring about the best result, particularly with white labour. There is a strong feeling among farmers in favour of diversified crops in lieu of depending solely upon cotton, and many raise their own food supplies; and greater attention is paid now than formerly to superior cultivation, and the yield per acre is consequently greater. Stock farming is one of the chief industries of Texas, and it is estimated that the number of cattle at present existing in the State exceeds 5,000,000, and the rearing of these animals has been for the last three or four years a business of great profit, and various calculations have been put forward showing what must be the profit to the owners of cattle simply by natural increase. Many of these animals are fed on "free range," *i.e.*, their food costs nothing, as the owners pasture them on unsettled lands, but with the increased value of land this system is likely to cease. Texas is well adapted for cattle breeding, and every season large numbers of young animals are driven north to the States of Kansas, Missouri, Illinois, Colorado, Nebraska, and other States, where they are fattened for the Eastern and European markets. A new phase of the cattle business is the slaughtering of animals in Texas, and sending them in refrigerating cars by railway to places of consumption, and this has been carried on to a large extent between the town of Victoria and New Orleans and other places. Consul Bridgett says that while Texas cattle find their way to England by way of Kansas City and Chicago, and thence to Boston and New York, nothing appears to be done to organise a direct trade to England, which is only eight days longer sea voyage. Australia and the Argentine Republic are shipping frozen meat to Europe, while Texas remains idle. Sheep farming is another large interest in western and south-western Texas, and the assessment rolls for 1882 give the number of sheep as 3,771,000, and the value put upon them is $7,000,000, or £1,456,000. Horses and mules abound in the State, but the largest horse ranches are in in western and south-western Texas. These animals are noted for their hardihood and powers of endurance. Blood stock is also being raised by several breeders, and it is claimed by them that parts of Texas are equal, if not superior, to the blue grass region of Kentucky. The number of horses and mules in the State amount to about 1,000,000, with a value of $22,680,000, or £4,717,000. Texas has a large amount of mineral lands, but as yet little use has been made of them. The chief minerals are coal, iron, and copper. Coal crops out in several sections of the country, and the area of the coal-fields is estimated at 20,000 square miles. Iron ore is abundant in many counties in Eastern Texas, and excellent marble is found near Paris, in Lamar county. Notwithstanding the fact that the greater portion of the State consists of immense prairies, Texas possesses the largest area of woodlands of any State in the Union. The timbered country is situated in Eastern Texas, and, according to the forestry reports, in 1880 there were 63,000,000,000 feet of standing pine, worth, on the average, at the mills, if sawn into planks, $12 per 1,000 feet. Besides pine, there are large quantities of cypress timber, both red and white, from which roofing shingles are made. Consul Bridgett says, in conclusion, that the vast territory of Texas, covering an area one-third larger than either France or Germany, with its diverse interests and resources, offers an unlimited field of enterprise for the capitalist, and equal advantages, in other ways, to persons of small means, to practical farmers with a little capital, and to the mechanic.

Correspondence.

EXPLORATION.

By way of supplement to the discussion on General Feilding's paper, the following remarks thereon are made. Mention may be made, in the first instance, that General Feilding was accompanied by myself on his journey across Australia to the Gulf of Carpentaria, the object of which was to explore for a proposed Australian Trans-Continental railway, to connect the capitals of the Colonies with a port on the northern coast.

In reply to General Baillie and Mr. H. Liggins the scientific instruments taken were those required by civil engineers and travellers in pursuit of geographical and geological information, and consisted of a pocket case of drawing instruments, by Elliott Bros.; aneroid barometers, by Casella; engineer's level and staff, by Troughton and Simms; a box, and a naval sextant, with stand, and artificial horizon; Sellar's compasses, and Negretti's thermometers; and along with these the Nautical Almanack, Raper's tables, and a star chart. The level had been used by myself in India and other countries, and stood rough usage without getting out of order. It was required on this particular journey to take sections of all the rivers crossed to the highest observable flood marks, for the purpose or estimating cost of bridging the same, with a sufficient water-way provided. The aneroid barometers used were chiefly for ascertaining the difference of height between the camp at Cloncurry and various points in the neighbouring mountainous districts. One barometer was left at the camp, to be read every hour during the

day, and a note made thereof, whilst we were away, sometimes two or three days, exploring with two other barometers. On returning, the difference of readings for the same time were taken, and the relative heights calculated therefrom. Across the plains, heights were not so much needed for a flying survey like ours, because it could be seen that easy gradients for the railway were obtainable. The naval sextant was required to determine the local time from sun observations in the forenoon or afternoon, when we were camping, and to take the meridian altitude of a favourable star at night, or early morning, to calculate the latitude. The sun being more or less vertical all the time, its meridian altitude could not be taken with a sextant and artificial horizon, because the angle is double, and greater than a reflecting instrument can measure. It was my intention to take a transit theodolite, by Elliott Bros., one highly prized and used for setting out railway curves and tunnels, which, in my opinion, is more useful than a naval sextant for a traveller, but being desirous of travelling as light as possible, the sextant only was taken. This had the usual stand, which is heavy, and may be dispensed with by substituting a metal rod, as shown to me by Mr. A. C. Gregory, the Australian traveller. He sticks the rod into the box used for transporting the instrument, and suspends the sextant by the side of the rod, and by means of a screw he can push the sextant further away from, or allow it to come nearer to, the rod till it is vertical with the star, and its reflection a mere speck in the mercury. The artificial horizon used was a very portable one, and kindly lent to us by Mr. A. C. Gregory. The mercury was contained in a bag, in a wooden box about four or five inches square and two inches deep. In the centre of the top of the box was a metal hole with a screw, and two other screws, one on each side of the box. On removing the centre screw, and turning the side screws which communicated pressure to the bag, the mercury oozed up into the trough. To make the mercury flow back again, all that was necessary to be done was to turn the side screws the reverse way. The cover was glass, framed with wood, and jointed to fold up flat and pack away with the mercury box. Although we had a good ship's chronometer, intended to calculate longitude, it was by my advice left behind, because no dependence could be placed upon its rate when transported across countries as it would have to be. With pocket compasses to take bearings of our courses, and estimating the distances by the rate at which we travelled, with occasional observations with the sextant, we succeeded in coming out at the point on the Gulf of Carpentaria, opposite Allen Island, that we aimed for.

With regard to the means of transport, waggons are useful for transporting stores in dry seasons across countries where there are tracks, and to take any of the party who might be ill or unable to ride on horseback; but for exploring new country they are, in my opinion, unsuitable, because in dragging them across creeks and gullies, and over difficult country, the strength and energy of both horses and men, which ought to be reserved, are worn out, besides time being wasted that might be devoted to the purposes of the expedition, in which more pleasure is taken. As to animals, it was my custom when in India to employ camels to take the tents and kit, and provide riding horses for myself and party. When exploring in Central America, riding and pack horses and mules only were employed, and the mules were most to be relied upon where food was scarce, because they managed to find for themselves something to eat, and keep in condition when the horses fell away and grew weak. Some big mules that were shipped at New Orleans and taken in vessels across the Gulf of Mexico were of little use; they would not cross streams with muddy sides, or climb up or go down steep and slippery places like the mules of the country. When exploring for railways in the Argentine Republic, only horses were available, and they answered well; but there were no hardships to undergo, and long distances could be travelled with ease when the floods were not out.

Of the various articles mentioned by General Feilding, I can speak highly of the steel cartridges, the compressed cakes of tea, the canvas water-bags with a neck of a soda-water bottle tied in one corner and plugged to travel with, the waterpoof bucket which, when required for use, had three sticks pushed down pockets at the sides to prevent them collapsing when full of water. General Feilding has omitted to mention nets to be worn over the face to prevent the innumerable flies getting into our eyes and inflaming them, and leather fringes for the horse's foreheads for the same purpose. One of the most useful articles was a zinc bucket used for boiling water, cooking food, making tea, and a number of other purposes.

Touching upon the signs of water, the screeching of the crow is the surest. It was very distressing to see the poor horses, when there was little for them to eat and obliged to go considerable distances through a very dry atmosphere without a drink, they seemed to know at times that they were nearing water by quickening their pace, and it is more than we could manage on some occasions to prevent them rushing headlong into it and lying down with their packs and saddles on. When their strength was failing them, the oftener and longer we had to spell in order that they might recruit.

Tea was found to be the most invigorating and refreshing beverage for the interior of Australia.

JOHN ROBINSON, M.Inst C.E.

Dock and Railways Engineer's Office,
Barry, Cardiff. March 16th, 1885.

His Excellency, the Governor of Bombay in Council, has appointed General T. Waddington (retired) to be Honorary Commissioner, and Mr. P. L. Simmonds to be Executive Agent for Bombay for the purposes of the forthcoming International Exhibition at Antwerp.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

MARCH 25.—"The Musical Scales of Various Nations." By A. J. ELLIS, B.A., F.R.S. Sir FREDERICK ABEL, C.B., D.C.L., F.R.S., Chairman of Council, will preside.

CANTOR LECTURES.

Monday Evenings at Eight o'clock.

The Fifth Course, "Carving and Furniture." By J. HUNGERFORD POLLEN.

LECTURES III. & IV. MARCH 23 & 30.—The Age of Gibbons, Boule, and that of their successors.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 23...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. J. Hungerford Pollen, "Carving and Furniture." (Lecture III.)

Surveyors, 12, Great George-street, S.W., 8 p.m. Adjourned discussion on Mr. R. W. Mann's paper, "The Enfranchisement of Urban Leases," and on Mr. H. Martin's paper, "Recent Proposals for Leasehold Enfranchisement."

Geographical, University of London, Burlington-gardens, S.W., 8½ p.m. Major T. H. Holdich, "Geographical Notes on Herat, and the Valleys of the Hari-Rud and Murghab." With Introduction by General J. T. Walker, late Surveyor-General of India.

Medical, 11, Chandos-street, W., 8½ p.m.

TUESDAY, MARCH 24...Royal Institution, Albemarle street, W., 3 p.m. Prof. Arthur Gamgee, "Digestion and Nutrition." (Lecture IV.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. Peter William Willans, "The Electrical Regulation of the Speed of Steam-engines and other Motors for Driving Dynamos."

Anthropological, 3, Hanover-square, W. 1. Mr. A. J. Duffield, "The Inhabitants of New Ireland and its Archipelago." 2. Mr. R. Brudenell Carter and Mr. C. Roberts, "Methods of Testing the Sight of Civilised and Savage Peoples."

WEDNESDAY, MARCH 25...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. A. J. Ellis, "The Musical Scales of Various Nations."

Geological, Burlington-house, W., 8 p.m. 1. Mr. Robert Kidston, "The Relationship of *Ulodendron*, Lindley and Hutton, to *Lepidodendron*, Sternberg, *Bothrodendron*, Lindley and Hutton, *Sigillaria*, Brongniart, and *Rhytidodendron*, Boulay." 2. Dr. Henry Woodward, "An almost perfect Skeleton of *Rhytina Stelleri*, obtained from the Pleistocene Peat Deposits on Behring's Island by Mr. Robert Damon."

Naval Architects (at the HOUSE OF THE SOCIETY OF ARTS), 12 o'clock. Annual Meeting. Address by the President, Reading of Papers, and Discussions.

Royal Society of Literature, 21, Delahay-street, S.W., 8 p.m. Mr. Percy W. Ames, "The Nature of Thought considered chiefly from Physiological Points of View."

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. C. O. Burge, "Indian Railway Construction and Maintenance."

THURSDAY, MARCH 26...Naval Architects (at the HOUSE OF THE SOCIETY OF ARTS), 12 o'clock, Morning Meeting. 7 p.m., Evening Meeting. Reading of Papers, and Discussions.

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Mrs. Shiel, "Physiology and the Laws of Health." (Lecture V.). "Respiration."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr James Orrock, "The English Art, with Illustrations."

Parkes Museum of Hygiene, 74A, Margaret-street, W., 8 p.m. Lecture on "Smoke."

Royal Institution, Albemarle street, W., 3 p.m. Prof. J. Dewar, "The New Chemistry." (Lecture XI.)

Telegraph-Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. Professor Oliver J. Lodge, "The Seat of Electro-motive Force in a Voltaic Cell."

College of Physicians, Pall mall East, S.W., 5 p.m. (Lumleian Lectures.) Sir Andrew Clark, "Some Points in the Natural History of Dry Pleurisies."

FRIDAY, MARCH 27...Naval Architects (at the HOUSE OF THE SOCIETY OF ARTS), 12 o'clock, Morning Meeting. 7 p.m., Evening Meeting. Reading of Papers and Discussion continued.

United Service Institution, Whitehall-yard, 3 p.m. Lieut.-Colonel J. Moody, "Recruiting for Her Majesty's Service."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Mr. Victor Horsley, "The Motor Centres of the Brain, and the Mechanism of the Will."

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. Students' Meeting. Mr. Fred. Platt, "The Compound Principle as applied to Locomotive Engines."

Quekett Microscopical Club, University College, W., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

Browning, University College, W.C. 8 p.m. Prof. E. Johnson, paper on "Sludge the Medium."

SATURDAY, MARCH 28...Royal Institution, Albemarle-street, W., 3 p.m. Mr. C. Armbruster, "The Life, Theory, and Works of Richard Wagner." With musical illustrations. (Lecture V.)

Physical, Science Schools, South Kensington, S.W., 3 p.m. 1. Mr. Jos. Edmundson, "Calculating Machines." (Illustrated by a collection of ancient and modern machines lent by their owners for the occasion.) 2. Exhibition of Instruments by Prof. Kennedy, Colonel E. D. Malcolm, Mr. Conrad W. Cooke and Mr. A. Hilger.

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Geologists' Association, 3 p.m. Visit to the Geological Museum of Dr. J. Channing Pearce, Manor-house, Brixton-rise. Demonstration by F. W. Rudler.

Journal of the Society of Arts.

No. 1,688. Vol. XXXIII

FRIDAY, MARCH 27, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The third lecture of the fifth course on "Carving and Furniture" was delivered on Monday evening, March 23rd, by Mr. J. Hungerford Pollen, who, after explaining the arrangements of the old country mansions, and the prominent position which carved wood occupied in their decoration, devoted special attention to the productions of the age of Gibbons and Boule.

The lecture was illustrated by photographs of examples shown on the screen by means of the lantern.

The lectures will be printed in the *Journal* during the summer recess.

FOREIGN & COLONIAL SECTION.

Commander Cameron's paper on "The Congo and the Conference, in reference to Commercial Geography," will be printed in the next number of the *Journal*.

Proceedings of the Society.

SIXTEENTH ORDINARY MEETING.

Wednesday, March 25th, 1885; Sir Frederick Abel, D.C.L., C.B., F.R.S., Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Dalyell, Hon. Robert Anstruther, C.S.I., LL.D., 21, Onslow-gardens, S.W.
Hardy, G. Hurlstone, Park-lodge, East Twickenham.
Head, John, F.G.S., 12, Queen Anne's-gate, S.W.
Hodges, Herbert J., Chesterfield-house, Barclay-road, Fulham, S.W.
Kendal, James, 106, Cheapside, E.C.
Pears, Andrew, Spring-grove, Isleworth.
Stenning, Allan E., East Grinstead, Sussex.
White, William Henry, Lower Condercum, Newcastle-on-Tyne.

The following candidates were balloted for and duly elected members of the Society:—

Clare, Octavius Leigh, Hindley-cottage, East Sheen, S.W.
Gilbert, William Henry Sainsbury, 9, Old Jewry-chambers, E.C.
Kirkaldy, John, 40, West India-road, E.
Partington, Charles Frederick, 47, Lower Belgrave-street, S.W.
MacWilliam, George Greenshields, 20, Bartlett's-buildings, Holborn, E.C.
Patterson, George, 85, Carleton-rd., Tufnell-pk., N.
Sharp, James, Carr-hall, Wyke, near Bradford.
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The paper read was—

ON THE MUSICAL SCALES OF VARIOUS NATIONS.

By Alexander J. Ellis, F.R.S.

I.—Introduction.

The title of this paper was meant to be "On the Musical Scales of *all* Nations." *All* is a big word, and I have had to withdraw it, and take refuge in the neutral term *various*. As I glance at Greece, Arabia, India, Java, China, and Japan, this term is at least not too comprehensive. The difficulties in collecting and co-ordinating information, even to this extent, have been many and great. Although some of the matter I have to bring to your notice may be found by those who know how to look for it, in papers already published, by far the greater part is entirely new. The very method by which the results have been obtained, and the language in which they are expressed, are also new, the results of my own investigations. I have been assisted throughout by the delicate ear of Mr. Alfred James Hipkins, of J. Broadwood and Sons. Indeed, I may say at the outset, that without his remarkable power of discriminating small intervals between tones of very different qualities, one of which in each comparison was often of very short duration, and without his great kindness in putting his faculty at my disposal, and his hearty sympathy in all my musical work, this paper could not have come

into existence for want of materials, and the only reason why I have not associated his name with mine at the head of it is, that I do not wish to make him responsible for the shape in which our joint work is produced. The calculations, the arrangement, the illustrations,* as well as the original conception, form my part. The judgment of ear, musical suggestions, and assistance in every way form his.

II.—Musical Scales.

In my "History of Musical Pitch" (*Journal of the Society of Arts*, 5th March and 2nd April, 1880, and 7th Jan., 1881), Art. 2, I defined "the pitch of a musical note to be the number of double or complete vibrations, backwards and forwards, made in each second by a particle of air while the note is heard;" and I gave a full account of the methods by which this is ascertained, and showed how, by means of a sufficiently long series of tuning-forks, first, their own pitch, and then the pitch of all other notes of sufficient duration which fall within their compass, can be ascertained to one vibration in ten seconds. I chiefly used the forks of the late celebrated Scheibler for that paper. For the present investigation I have employed a much longer series of forks, with their pitch ascertained from those of Scheibler within that limit. Further, in Art. 3, I defined *musical* pitch to be "the pitch of any named musical note which determines the pitch of all the other notes in a particular system of tuning." By that *system* we are therefore able to tune all the notes on an instrument. These notes, when sounded in succession from the lowest to the highest—that is, from that which has the smallest to that which has the largest pitch number—forms the *scale* of the instrument, from which are selected the notes used for any piece of music forming the scale of that composition. The word scale properly means *ladder*, because the notes thus sounded gives us the sensation of ascending by definite distances. An *interval* between any two notes is the sensation of the distance passed over in proceeding

* The reading of this paper was entirely occupied by illustrations connected by the fewest possible explanations, because it was considered more important that the audience should actually hear the scales than be merely spoken to about them. But to make this at all intelligible to a reader I have been obliged to extend my paper to an unusual length. The illustrations were rendered on several instruments.

1. A *Dichord*, an instrument of two strings, most kindly constructed for me, with a beautiful sounding board, by Messrs. John Broadwood and Sons. The vibrating wires were No. 2, gauge 3-10th millimetres, about 1-80th inch, the thinnest drawn, and had a vibrating length of 1,200 millimetres (of which 3,048 make 10 feet). The nut was raised 7 mm., and the bridge 24 mm. from the sounding board. The wires were fastened as on a pianoforte, and screwed to pitch C 132 vib., or tenor C, by the usual tuning hammer. A number of laths, about 5 mm. thick and 915 mm. long, were constructed to serve as finger boards. On one of these was first marked through two octaves the place where the wire should be stopped by the finger (or, rather, side of the thumb nail, to be more accurate) to produce the notes of the just major scale, calculated on the usual hypothesis, that the numbers of vibrations would be inversely proportional to the lengths. Owing to the necessity of having the wires to stand some distance from the finger-board (as on the violoncello), the increased tension arising from bringing the wire to the board in each case sharpened the note considerably. To overcome this difficulty, the notes were played on a justly intoned harmonical, tuned from forks which had been accurately adjusted by myself, and then, as each note was sounded, Mr. Hipkins marked off the position where he had to stop the wire for perfect unison. From these I was able to calculate and mark off, on a geometrical scale, the exact position for stopping the string, so as to produce an interval of any given number of cents (see this term explained in Art. 3), and hence draw the finger board for any musical scale whatever. Marking each such scale on its own board, I could thus render any scale distinctly audible. This must have been entirely new to almost every one of the audience.

2. Five *English Concertinas*, tuned for me with great care by Mr. Saunders, of Messrs. Lachenal and Co., the first concertina house in London. The English concertina had, for my purposes, two important advantages over any other instrument. First, I had been familiar with it from boyhood, having possessed some of the earliest concertinas made. Second, it has 14 notes to the octave, and was hence well adapted to introduce extra notes for various purposes. These five instruments were tuned thus: *a*. Meantone, giving the old unequal temperament with extra *A* flat and *D* sharp. *b*. Equal and Bagpipe, giving the complete equal temperament, and also the Bagpipe scale, and Meshaqah's Arabic scales, allowing me to illustrate these by playing airs. *c*. Just, giving the accurate harmonic scales of F, C, G major, and E major and minor, enabling me to illustrate the ancient Greek tetrachords. *d*. Pythagorean, containing the 14 notes tuned as a succession of perfect Fifths, enabling me to illustrate the Pythagorean or later Greek form of the several Greek modes, and also most of the the mediæval Arabic scales. *e*. Javese, the white keys giving the Salendro, and the black the Pelog scales. This was tuned from forks adjusted by myself to the pitches of the Javese instruments which were played at the Aquarium in London, in 1882, as ascertained by Mr. Hipkins and myself from careful examination. This enabled me to play several Javese airs.

3. An Indian *Sitâr*, or long-necked guitar, most kindly presented to me by H.H. the Raja Ram Pal Singh, who had himself played upon it to Mr. Hipkins and myself, to enable us to record some Indian scales. One of these scales was set upon the Sitâr so that it could be played, the others were placed on the Dichord.

4. Two *Vinas*, kindly lent me by M. Victor Mahillon, of Brussels.

5. A *Gambang* or *Balafong*, that is, a wood harmonicon, played by a hammer, sent direct from Singapore to Mr. Hipkins, who kindly lent it for this purpose. As instruments of this kind are much used in the East, and I gave several scales obtained from them, this enabled me to show the nature of their construction and tone.

6. A *Koto*, the national Japanese instrument, also kindly lent by Mr. Hipkins, tuned for the occasion by the musicians of the Japanese Village.

7. A small Chime of Chinese Bells, and a set of Japanese Pitch-pipes, kindly lent by Mr. Hermann Smith.

from the first note to the second. It is measured properly by the ratio of the smaller pitch number to the larger, or by the fraction formed by dividing the larger by the smaller. When these ratios are known for each successive pair of notes, the scale itself is known, for means then exist for tuning the whole scale when one of its notes is given. Clearly, if we assume, for the purposes of calculation, that the lowest note makes one vibration in a second (which could not be heard as a note), the ratios mentioned would give the corresponding numbers of vibrations for each note, and these all multiplied by the real audible number of vibrations in the lowest note, would give the *absolute* pitches of the actual notes heard. These ratios, therefore, are the important matters to ascertain, and they are said to give the *relative* pitch of each note in the scale. The absolute numbers, which is what engaged my attention last time, are now of little consequence. We do not want to know how to tune at any particular pitch, but how to tune at any pitch whatever. Hence it is the law which determines the relative pitch that we wish to find, or, in other words, the system of ratios or of their equivalents.

III.—Cents.

Now these ratios convey no conception whatever to the musician, who, without considerable instruction, can attach no musical meaning to such ratios as 2 : 3, 3 : 4, 4 : 5, 5 : 6, 6 : 7, 7 : 8, 8 : 9, 9 : 10, and so on. Hence some other way of expressing them is necessary, especially for describing scales. To that end I must anticipate somewhat. It will not be, perhaps, too great an assumption to presuppose that every one present is acquainted with the pianoforte, and knows that it is divided into sets of tones called octaves, and that there are 12 digitals or finger keys to each octave, 7 long and white, 5 short and black. But, perhaps, every one may not know (as he ought to know) that the object of the tuner is to make the interval (or sensation of distance or ascent) between any two notes answering to any two adjacent finger keys throughout the instrument precisely the same. The nearer he succeeds the better the tuner. The result is called *equal temperament* or tuning, and is the system at present used throughout Europe. (See "History of Musical Pitch," Art 4. and Appendix 1). For the purposes of measurement, I must assume that the tuner has succeeded, although I am bound to say that no tuner ever has as yet succeeded perfectly, on account of the great difficulty to be overcome. Then we say that the interval of an Octave is divided into twelve equal intervals called Semitones. Now I must go a step further. Suppose a piano made of such a gigantic size that we could interpose 99 smaller finger keys between any two at present existing, and that we could tune these at exactly equal intervals, called *cents*, so that 100 cents would form an equal semitone. It is as well to know at once that this is impossible*. No ear has yet succeeded in hearing the interval of 1 cent between two notes played in succession. Even the interval of 2 cents requires very favourable circumstances to perceive, although 5 may be easily heard by good ears, and 10 to 20 ought to be at once recognised by all singers and tuners. When the two notes are played at the same time, these 2 cents make a distinct difference in consonances, and 5 cents are felt to be out of tune. The tuner has constantly to deal with intervals of from 2 to 22 cents, and he corrects his ear by playing the notes together. If, then, I say that a certain interval has 316 cents, I mean that it contains 3 semitones (counted by the keys on a piano) and 16 cents or a very little more. But how are we to determine the number of cents? By finding the interval ratio already mentioned, which is best ascertained from the absolute pitch numbers of each note, and may be approximately ascertained by taking the ratio of the sounding lengths of two pieces of the same musical string, when they are in unison with the two notes as determined on an accurate monochord. Having found these two numbers, the discovery of the number of cents is a mere matter of arithmetic.† When the numbers of cents have

* Although this is quite impossible on a piano, we may approximate very closely to a conception of such a division on my Dichord, which is tuned to tenor *C* 132 vibrations. Take two notes as *D* and *D* sh. an equal semitone apart in the lower portion of the scale. Their stopping places are 2½ inches apart. Now, if the finger be glided over this interval after the string is plucked, a gradual and continuous alteration of sound is heard in passing from *D* to *D* sh., and it is evident that if the finger stop anywhere a continuous tone will be produced. Now, to divide 2½ inches into a hundred parts, gives the very sensible distance of the fortieth part of an inch for each. And if we placed the finger at each we should get intervals almost (not quite) 1 cent apart. How small this interval is was shown by stopping at intervals of 10 cents, or a quarter of an inch, in passing from *D* to *D* sh.

† If of the two numbers expressing the interval ratio, 3 times the larger is *not* greater than 4 times the smaller, multiply 3,477 by their difference, and divide by their sum to the nearest whole number, adding 1 to the result if over 450. Thus if the ratio is 4 : 5 (where 3 times 5 the larger = 15, is less than 4 times 4 the smaller number = 16), the difference is 1, and sum 9, and dividing 3,477 by 9, the result is 386, the cents required. If the ratio is greater than 3 : 4 and les

been ascertained by the process described in the footnote, a scale, which I particularly leave unnamed, is written thus :—

Vib.	270		308		357		411		470		540
Cents	I	228	II	256	III	244	IV	232	V	240	I
Sums	0		228		484		728		960		1200

Here I, II, &c., are the notes of the particular scale, of which there are here five, I' being the octave of I. The numbers *between* these note-symbols show the number of cents in the interval from one to the other. The numbers *under* them show the number of cents in the interval from I to the note in question. The number *above* is the absolute pitch number of the note as already defined, that is, the number of vibrations which it makes in a second, as found from observations. But this may be omitted when merely the relative pitch is wanted.

than 2 : 3, multiply the larger number by 3, and the smaller by 4, proceed as before, and finally add 498 to the result. Thus for 32 : 45, multiply 45 by 3, and 32 by 4, giving 128 : 135, difference 7, sum 263. Then $7 \times 3477 \div 263$ gives 92, and $92 + 498$ gives 590, the cents required. Lastly, if the ratio exceeds 2 : 3, multiply the larger number by 2 and the smaller by 3, and proceed as in first case adding 702 to the result. Thus for 5 : 8, take $3 \times 5 : 2 \times 8$ or 15 : 16; difference 1, sum 31; then $3{,}477 \div 31 = 112$, and this added to 702, gives 814 the required number of cents. This process is sometimes very convenient, but when a large number of results have to be obtained, always tedious. In this case, those who can use logarithms, will find the following table very simple, and it will give the result to one-tenth of a ceut.

TO CONVERT LOGARITHMS INTO CENTS, AND CONVERSELY.

Cents.	Logarithms.	Cents.	Logarithms.	Cents.	Logarithms.	Cents.	Logarithms.
100	·02509	10	·00251	1	·00025	·1	·00003
200	·05017	20	·00502	2	·00050	·2	05
300	·07526	30	·00753	3	·00075	·3	08
400	·10034	40	·01003	4	·00100	·4	10
500	·12543	50	·01254	5	·00125	·5	12
600	·15051	60	·01505	6	·00151	·6	15
700	·17560	70	·01756	7	·00176	·7	18
800	·20069	80	·02007	8	·00201	·8	20
900	·22577	90	·02258	9	·00226	·9	23
1000	·25086						
1100	·27594						
1200	·30103						

Subtract the logarithms of the pitch numbers or of the numbers of their ratio. Thus for 32 : 45, log 45 = 1·65321, log 32 = 1·50515, difference ·14806, the next least log in the table, ·12543 gives 500 cents. Subtract this from former log, result ·02263, next least ·02258, giving 90 cents, total 590 cents to the nearest cent as before. But we can now, if we like, go a step farther, and subtracting the two last logs we get ·00005, which in the last column corresponds to ·2 cents. Final result 590·2. It is, as a general rule, unnecessary to go beyond the nearest whole number of cents.

The following are a few of the best known intervals expressed in cents and ratios for comparison with those which follows :—

Cents.	Ratios.	Name.
2	32768 : 32805	Skhisma.
22	80 : 81	Comma (of Didymus).
24	524288 : 531441	Comma of Pythagoras.
27	63 : 64	Septimal Comma.
50	239 : 246	Quartertone.
70	24 : 25	Small Semitone.
90	243 : 256	Pythagorean Limma.
92	128 : 135	Small Limma.
100	‖ 84 : 89	Equal Semitone.
112	15 : 16	Diatonic Semitone.
114	2048 : 2187	Apotome.
151	11 : 12	Trumpet three-quarter Tone.
182	9 : 10	Minor Second.
200	‖ 400 : 449	Equal Tone.
204	8 : 9	Major Second.
267	* † 6 : 7	Septimal minor Third.
300	‖ 37 : 44	Equal minor Third.
316	* 5 : 6	Just minor Third.
355	22 : 49	Zalzal's neutral Third.
386	* 4 : 5	Just major Third.
400	‖ 50 : 63	Equal major Third.
408	64 : 81	Pythagorean major Third.
476	243 : 320	Grave Fourth.
498	* 3 : 4	Just Fourth.
500	‖ 227 : 303	Equal Fourth.
583	* † 5 : 7	Septimal Fifth.
590	32 : 45	Just Tritone.
600	‖ 99 : 140	Equal Tritone.
680	27 : 40	Grave Fifth.
700	‖ 289 : 433	Equal Fifth.
702	* 2 : 3	Just Fifth.
704	160 : 238	Acute Fifth.
800	‖ 63 : 100	Equal minor Sixth.
814	* 5 : 8	Just minor Sixth.
853	11 : 18	Zalzal's neutral Sixth.
884	* 3 : 5	Just major Sixth.
900	‖ 22 : 37	Equal major Sixth.
906	16 : 27	Pythagorean major Sixth.
969	* ‖ 4 : 7	Septimal or harmonic minor Seventh.
996	9 : 16	Just minor Seventh.
1000	‖ 55 : 98	Equal minor Seventh.
1088	8 : 15	Just major Seventh.
1100	‖ 89 : 168	Equal major Seventh.
1110	128 : 243	Pythagorean major Seventh.
1200	* ‖ 1 : 2	Octave.

* Consonant intervals, the rest are dissonant.

* † The consonance of these intervals is disputed.

‖ Equally tempered intervals. The ratios assigned to these intervals (with the exception of the Octave) are only very close approximations, the real ratios being incommensurable, or not expressible in whole numbers.

IV.—Theory and Practice.

Of course practice preceded theory in music as in everything else. The sound of a Fourth was perfectly well known to singers and lyrists, long before it was discovered that the whole length of a string and three-quarters of its length, when plucked, would give this very interval. But this once found, theory followed rapidly, and intervals were defined by lengths of string with great minuteness. It was the ratio of these lengths of string that was used to determine the intervals; and it is only of recent years that these lengths were found to be inversely proportional to the pitch numbers of the notes, and then these pitch numbers, which were applicable to all musical sounds, and not to those of strings only, became exclusively employed. The property just named, that the pitch numbers of notes are inversely proportional to the length of strings producing them, is, unfortunately, quite true only for a heavy perfectly flexible and elastic mathematical line, limited by mathematical points, and any attempt to divide a real string of wire or catgut by bridges or frets fails for several reasons. In the case of frets, the pressure of the finger behind the fret increases the tension of the string and increases the pitch. This circumstance is of great importance in the Indian Vina, which has very high frets, so that the pressure of the finger behind the fret can easily raise the pitch of the note by a Semitone, that is, 100 cents or more. Even in the modern guitar the intervals are sensibly sharpened. Hence the lengths of the strings for the principal intervals can only be termed a happy guess; and it remained for quite recent observers, such as Helmholtz, to establish, by ingenious instruments, that the actual ratios of vibrations for the consonant intervals was precisely those given for them in the last table, and could not be any other. Thus it was possible to have a theory of the scale. It is not my purpose to go into that theory. It would lead me much too far. But the theory implied exact measurements, all very well for instrument makers, but not for musicians, who have only one standard to go by, their own ear, that is, their own appreciation of interval or relative pitch. Some musicians, like the Indian, repudiate all measurement and all arithmetic from the first, and leave everything to the judgment of the ear. In this country we are familar with the pianoforte, harp, and violin, all of which are tuned exclusively by ear. For the harmonium, indeed, "beats" are available, but they are rarely used. On the contrary, organ tuners are accustomed to a rough appreciation of the occurrence of beats, but few of them know the exact numbers, or understand how to employ them properly. Hence, as we may expect, tunings by ear, or the actual notes produced in the scale by a tuner, seldom or never give precisely those intervals which theory lays down. It seemed to me advisable, before trying uncivilised or semi-civilised nations, to see how well good English tuners could tune. Mr. Hipkins, who has the best possible means of knowing, says that it takes a quick man *three years* to learn to tune a piano properly. We may take it for granted, then, that most pianos are improperly tuned. The following examples (1, 2, 3, 4) give an octave on the piano, as tuned by Broadwood's tuners—(1) was a cottage piano tuned a fortnight previously, but not played on during that time, (2, 3, 4) were grand pianos tuned especially for this examination, (5) was an organ tuned a week previously by one of Mr. Hill's tuners and only played on once, (6) an harmonium tuned by one of Messrs. Moore and Moore's tuners, and (7) an harmonium tuned

Examination of Equal Tuning.

Note.	*C*	*C* sh	*D*	*D* sh.	*E*	*F*	*F* sh.	*G*	*G* sh.	*A*	*A* sh.	*B*	*C*
Theory.	0	100	200	300	400	500	600	700	800	900	1000	1100	1200
1	0	96	197	297	392	498	590	700	797	894	990	1089	1201
2	0	99	200	305	411	497	602	707	805	902	1003	1102	1206
3	0	100	200	300	395	502	599	702	800	897	999	1100	1200
4	0	101	199	299	399	500	598	696	800	899	999	1100	1200
5	0	101	192	297	399	502	601	702	806	898	1005	1099	1201
6	0	98	200	298	396	498	599	702	800	898	999	1099	1199
7	0	100	200	300	399	499	600	700	800	900	1001	1099	1200

as a standard a year previously under the favourable conditions of a constant blast, with strict calculation and counting of beats by Mr. Blaikley, of Boosey's. Only the cents in the interval from the lowest note are given in each case.

These are very good specimens indeed, but, with the exception of the last, they are not quite perfect. In the last it is difficult to state whether the tuning or the measurement was occasionally in error by one cent.

For a critical consideration of these results, and rules by which these errors may be avoided, as time would fail me to enter upon the subject, I must refer to Appendix XX., Sec. G., of my new edition of Helmholtz's great work "On the Sensations of Tone," which is almost all in type, and will soon be published by Messrs. Longman.

Now, in order to find the scales which I have to communicate to-night, there were two courses only open—theory and practice. For Greece, Arabia and Persia, India and Japan, treatises exist, giving the scales more or less accurately; probably also for China, but they were not accessible to me. Where I could find these couched in intelligible language (very far from being generally the rule), I was glad to follow them, as they showed what those best able to judge considered to be aimed at in tuning. But the treatises that furnish accurate numbers are confined to Greece and Arabia, with Persia. Indian treatises rather ostentatiously eschew arithmetic, so that in reality their theory depends on oral tradition. In India, then, in China, in Java, and the various savage countries, there was nothing accessible but the instruments, and perhaps (as at the Aquarium in 1882, the International Health Exhibition of 1884, and the Japanese Village in 1885), native musical performers on a visit to England. Now any musical instrument on which a native can play to the observer furnishes a set of notes actually produced, and these can have their pitch numbers determined with more or less certainty. In this way I was fortunate enough to get thirteen scales, five Indian, seven Chinese, and one Japanese, all recorded in numbers of vibrations, by the kind help of Mr. Hipkins.

Instruments without a native performer seldom record themselves. Wind instruments, of course, require a native practised musician to blow, because the pitch can be greatly varied by the style of blowing. Stringed instruments without frets, or with movable frets, are also worthless without a native player. A stringed instrument with fixed frets (like the ordinary guitar), is to a certain extent available. If there are several strings, the law of tuning them is generally unknown. But if there are many frets on one string, enough to cover an octave (as on the guitar), then by measuring the vibrating lengths of the strings from the bridge to the edge of the fret next to the bridge, we can approximate to the relative pitch of the scale of notes which would be produced by sounding the string when properly stretched. The absolute pitch it is of course impossible to discover. That can only be obtained by help of a native performer, and would probably differ from one performer to another, for I have discovered nothing like a standard pitch anywhere. We have not yet arrived at fixing a standard pitch even for Europe. But by stringing the instrument over the frets, tuning it when open to a convenient pitch, and after stopping it at the frets in succession, determining the pitch of the notes heard, we can approximate more closely to the relative pitch intended. The different natures of the strings—wire of various thickness, steel or brass, gut, tightly corded silk (used in China and Japan)—all tend to vary not only the absolute pitch of each note, but also necessarily the intervals between them. Moreover, it is exceedingly difficult to determine identity or minute differences of pitch between notes with qualities of tone so different as those of plucked strings and tuning forks.

There are some instruments which play themselves. Anyone with proper tuning forks could count the pitch of the notes in a piano, dulcimer, harmonium, or organ, when they have once been tuned, provided they have not since had an opportunity to get out of tune, as such instruments so easily have—the harmonium least. The Chinese Shêng (and Japanese Shô) are reed instruments, not easy to sound certainly, but presumably rendering very nearly the sounds to which they have been tuned. The main instruments of uncivilised music, however, are flutes, bells, gongs, and harmonicons, consisting of bars of wood or metal. It is the last which have enabled us to obtain the pitch of the notes used even without the assistance of native players. Unfortunately, such harmonicons are apt to fall out of tune, and their intonation is injured by travelling, and (especially the wooden ones) by damp.

Hence there is no practical way of arriving at the real pitch of a musical scale, when it cannot be heard as played by a native musician; and even in the latter case, we only obtain that

particular musician's tuning of the scale, not the theory on which it was founded. To reverse the process, to go back from the best we can do with the instrument to an hypothesis concerning the relations intended, is very risky indeed. We certainly ought to do the best we can in this way, but we should never forget to give the observed data whence our hypothesis is derived.

After all, we have only determined the notes used, not the scales employed for any piece of music. It would be impossible, from our knowing the twelve semitones to the octave used in Europe, to determine the double form of the major scale (without and with the grave Second), and the triple form of the minor scale (without and with the major Sixth and Seventh), not to mention the so-called ecclesiastical modes. So in other countries. Here we are thrown entirely on theorists or information from natives, and where these fail us, we only know the notes employed, not the scales made by selecting some of them. In a few cases these are known, but in others we can only guess.

There are, however, two distinct kinds of scales, considered as divisions of the Octave used in playing airs. In the first, between a note and its Octave, six notes are interposed, and the Octave derives its name from the circumstance of being the eighth note, including both extremes. Occasionally two or more notes are left out, and occasionally one to three are inserted as alternative notes. But the main run of the scales consists of seven notes. These scales are called *heptatonic*, and are prevalent in Europe, Arabia, India, and other places. The next great division inserts only four notes between the first and what, from European habits, we still term the Octave, which, however, is now the sixth note, both inclusive. These scales have in later times been often filled up by inserting two other notes; but these are clearly intrusive, and in the most typical case, Java, it has not been done. These scales are therefore termed *pentatonic*. They are found in the South Pacific, Java, China and Japan, and it is believed, from the nature of older Scotch, Irish, and Welsh melodies, were used by the Celts.

First Division.—Heptatonic Scales.

V. — Ancient Greece and Modern Europe.

Of the music of Egypt we know nothing; the instruments preserved, and their pictures, do not suffice to give a scale. We cannot tell what influence Egypt had on Greece. We do not know whence Greece derived her music, though Persia is a possible source. I am not going into a critical examination of the Greek scale. It does not at all form a part of my investigations.

The original Greek division depended on the interval of a Fourth, that is, the interval between the tones derived from any length of a string, and three-quarters of that length, containing 498 cents. The interval was too large for musical purposes, and hence one or two notes were always interposed. To represent these in systematic notation would require a long explanation, which would be out of place. I use therefore the ordinary notation *B C D E F G A* with sh, ssh, fl, ffl, for sharp, double sharp, flat, and double flat, leaving the numbers of cents interposed between any two notes to mark the interval and point out its relative value with precision. Of the 11 forms of the tetrachord given by Helmholtz, only the most usual 7 need be considered. These give the following "Tetrachords," or divisions of a Fourth, literally "four strings."

1. Of Olympos	*B*	112	*C*	286	*E*.				
2. Old Chromatic ..	*B*	112	*C*	70	*C*sh	316	*E*.		
3. Diatonic	*B*	112	*C*	204	*D*	182	*E*.		
4. Of Didymus	*B*	112	*C*	182	*D*	204	*E*.		
5. Doric	*B*	90	*C*	204	*D*	204	*E*.		
6. Phrygian	*B*	182	*C*sh	134	*D*	182	*E*.		
7. Lydian	*B*	182	*C*sh	204	*D*sh	112	*E*.		

Two of these tetrachords of the same kind, with a Tone of 204 cents, either placed before or after, or else between them, give an octave and are the foundation of the Greek heptatonic scale in its various modes. The distinctive differences of intonation, however, rapidly disappeared, and all the scales came to be played with the Doric tetrachord, known as Pythagorean, which for most purposes may be sufficiently represented by our ordinary equally tempered scale. This produced the following seven modes, in which the intervals occur in the same order as in the major scale begun on each of its degrees in succession. They are here given, however, as if they all began with *C*, and flats are introduced to render the intervals correct. The cents of the intervals are, as before, placed between the notes. The name of the mode derived from the note with which the major scale of *C* must be begun, is prefixed, then follows the ancient Greek name, the ecclesiastical name as wrongly given by Glarean, but usually adopted, and Helmholtz's

new names. For particulars refer to my second edition of Helmholtz, pp. 262-272.

LATER GREEK MODES.

1. *C* mode, or ancient Lydian, Glarean's Ionic, Helmholtz's mode of the First or major mode. *C* 204 *D* 204 *E* 90 *F* 204 *G* 204 *A* 204 *B* 90 *c*.
2. *D*-mode, or ancient Phrygian, Glarean's Doric, Helmholtz's mode of the minor Seventh. *C* 204 *D* 90 *E* fl 204 *F* 204 *G* 204 *A* 90 *B* fl 204 *c*.
3. *E*-mode, or ancient Doric, Glarean's Phrygian, Helmholtz's mode of the minor Sixth. *C* 90 *D* fl 204 *E* fl 204 *F* 204 *G* 90 *A* fl 204 *B* fl 204 *c*.
4. *F*-mode, or ancient Syntonolydian, Glarean's Lydian, Helmholtz's mode of the Fifth. *C* 204 *D* 204 *E* 204 *F* sh 90 *G* 204 *A* 204 *B* 90 *c*.
5. *G* mode, or ancient Ionic, Glarean's Mixolydian, Helmholtz's mode of the Fourth. *C* 204 *D* 204 *E* 90 *F* 204 *G* 204 *A* 90 *B* fl 204 *c*.
6. *A*-mode, or ancient Eolic, Glarean's Eolic (likewise), Helmholtz's mode of the minor Third or minor mode. *C* 204 *D* 90 *E* fl 204 *F* 204 *G* 90 *A* fl 204 *B* fl 204 *c*.
7. *B*-mode, or ancient Syntonolydian, Glarean's Lydian (as for the *F*-mode), Helmholtz's mode of the Fifth. *C* 90 *D* fl 204 *E* fl 204 *F* 90 *G* fl 204 *A* fl 204 *B* fl 204 *c*.

Now, different as all those scales are in character, mainly shown by the final cadence, they all agreed in one point. They were purely melodic. They could not be sung in harmony, as in the modern chorale or part-song. To do this properly, it was necessary to alter all the intervals slightly. The principles on which this was possible are fully explained in my second edition of Helmholtz, App. XX., Sec. E, and cannot be intruded here. The final result, however, may be added. In this the *C*-mode was retained, and the others were fused into the *A*-mode, to which three forms were given.

1. Major mode, harmonic, compare with the *C*-mode. *C* 204 *D* 182 *E* 112 *F* 204 *G* 182 *A* 204 *B* 112 *c*.
2. Minor mode, descending form, harmonic, compare with the *A*-mode. *C* 204 *D* 112 *E* fl 182 *F* 204 *G* 112 *A* fl 204 *B* fl 182 c.
   The same, ascending, first form. *C* 204 *D* 112 *E* fl 182 *F* 204 *G* 112 *A* fl 274 *B* 112 *c*.
   The same ascending, second form, to avoid the difficult interval of 274 cents between *A* fl and *B*. *C* 204 *D* 112 *E* fl 182 *F* 204 *G* 182 *A* 204 *B* 112 c.

All these forms give beautiful consonances, which may be heard from almost any unaccompanied chorus, especially of Tonic Sol-faists, but the consonances are greatly injured by the equal temperament which reduces the European scales to the following:—

1. Major mode. *C* 200 *D* 200 *E* 100 *F* 200 *G* 200 *A* 200 *B* 100 *c*.
2. Minor mode, three forms:—
   C 200 *D* 100 *E* fl 200 *F* 200 *G* 100 *A* fl 200 *B* fl 200 *c*.
   C 200 *D* 100 *E* fl 200 *F* 200 *G* 200 *A* fl 300 *B* 100 *c*.
   C 200 *D* 100 *E* fl 200 *F* 200 *G* 200 *A* 200 *B* 100 *c*.

This intonation, as I explained in my paper on the "History of Musical Pitch," is only about forty years old in England. The scales played before that time at the Philharmonic concerts, and on all organs, though probably never heard from unaccompanied part singers, were in "meantone intonation," or—

1. Major mode. *C* 193 *D* 193 *E* 119 *F* 194 *G* 193 A 193 B 117 *C*
2. Minor mode in three forms:—
   C 193 *D* 117 *E* fl 193 *F* 194 *G* 117 *A* fl 193 *B* fl 193 *C*
   C 193 *D* 117 *E* fl 193 *F* 194 *G* 117 *A* fl 269 *B* fl 117 *C*
   C 193 *D* 117 *E* fl 193 *F* 194 *G* 193 *A* 193 *B* 117 *C*

The object of all these changes was to reduce the number of necessary notes in the octave to 12. The last, or mean tone system, perfected by Salinas in 1577, prevailed over Europe for nearly 300 years. As long as only three sharps, *F* sh, *C* sh, and *G* sh, and two flats, *B* fl and *E* fl, were required, it admirably answered its purpose of furnishing organs with endurable harmonies. But modern music requires perfectly free modulation, and the equal temperament was the only one which would furnish this within the limits of 12 notes to the octave. Hence, notwithstanding the harshness of its chords, arising from the undue sharpness of its major Third, Sixth, and Seventh, it has prevailed universally, and many modern musicians are not even aware of its nature and defects, or that there ever was any other possible intonation.

VI.—PERSIA, ARABIA, SYRIA, AND SCOTTISH HIGHLANDS.

Of the ancient Persian scale we know nothing, but it was most probably the progenitor of the older Greek. At the earliest period of which we have precise knowledge, the writings of Al Farabi (who died A.D. 950),

give an account of the Lute, Tambours (long-necked guitars) of Bagdad and of Khorassan, the Flute, and Rabāb (a two-stringed viol). These have been published by Prof. J. P. N. Land, of Leyden, in Arabic, with a French translation under the care of M. Goeje, and a preliminary dissertation.*

The Arabs and Persians—for we must consider their systems identical in Al Farabi's time—had very various scales which not only could not be played together, just as our major and minor scales cannot be played together, but which were composed on such different principles for different instruments, that two instruments of different kinds could not be tuned to play the same scale together. They must, therefore, have been simple accompaniments for the voice, not in our modern sense of accompaniment (for there was and is no notion of harmony), but merely as steadiers of the voice, touching the notes that had to be sung, or else instruments for solo performance. We must, therefore, take them separately.

(1.) *The Lute* (*al'ood*, whence our word *lute* is derived). An instrument like the European lute, with four, and subsequently five, strings, nearly touching at the nut, and spreading out at moderate angles, so as to be well apart at the striking place. This was originally tuned in Fourths, each successive string being a Fourth higher than the next lower. A series of ligatures, answering to frets, were tied across the finger board. The places were at an early time, though perhaps not originally, determined so as to give on each string the Greek tetrachord of I 204 II 204 III 90 IV, where I, II, &c., represent the names of the notes. Of these I occupied the open string, II was stopped by the first, III by the fourth, and IV by the little finger, after which, and the string, they were named. Theoretically the note II used $\frac{8}{9}$ of the string, the note III used $\frac{8}{9}$ of this or $\frac{64}{81}$ of the whole length, and the note IV. used $\frac{3}{4}$ of the whole string. Practically, this would have made the notes too sharp, hence doubtless the position of the frets was accommodated as on the Japanese Biwa, which is an existing form of Al Farabi's lute. Calling the notes for the first or *C* string, *C* 204 *D* 204 *E* 90 *F*; those for the next, or *F* string, would be *F* 204 *G* 204 *A* 90 *B* fl; for the third, or *B* fl string, *B* fl 204 *C* 204 *D* 90 *E* fl; and for the fourth, or *E* fl string, *E* fl 204 *F* 204 *G* 90 *A* fl. The first octave, then, was *C* 204 *D* 204 *E* 90 *F* 204 *G* 204 *A* 90 *B* fl 204 *C*, the Greek *G*-mode (see Sect. V), with which Al Farabi was quite familiar, using the Greek names. Observe that the middle finger had nothing to do. The old plan was to introduce a fret for it between *D* and *E*, at *E* fl, a tone 204 cents flatter than *F*, so that the length of string for *E* fl was $\frac{9}{8}$ the length for *F* (corrected of course). On the second string there was, therefore, a corresponding *A* fl. This gave as the scale—

C	204	*D*	90	*E* fl	114	*E*	90	*F*	204	*G*	90	*A* fl	114	*A*	90	*B* fl	204	*C*
0		204		294		408		498		702		792		906		996		1200

But this old "middle finger" note did not please. First a Persian modification was tried, by tying a ligature halfway between those for 204 and 408 cents, which would (theoretically) give 303 cents on the first string, and 801 cents on the second. But these notes, which were as nearly as possible our own equally-tempered *E* fl 300, and *A* fl 800, also grew out of favour. Something sharper was required. Possibly they longed for the perfect minor Third *E* fl 316, and minor Sixth *A* fl 814. But they went much sharper. One Zalzal, a celebrated lutist, who died a century and a half before Al Farabi, tied a ligature halfway between the Persian 303 cents and the Greek 408 cents, and got a tone of 355 cents on the first and 853 cents on the second string. These notes became of great importance in Arabic music, and effectually distinguished this older Arabic form from the later Greek. The scale now practically became—

C	204	*D*	151	E°	143	*F*	204	*G*	151	A°	143	*B* fl	204	*C*
0		204		355		498		702		853		996		1200

where E°, A° represent for the moment these new tones. To this important scale, quite different from anything we have yet met with, I shall have to devote considerable attention presently.

Designating the strings as simply FIRST (or lowest), SECOND, THIRD, FOURTH, and FIFTH, and the notes as "Open, Index, Middle, Ring, Little"—namely, played with those fingers—as more generally intelligible than the Arabic names used by Professor

* *Recherches sur l'histoire de la Gamme Arabe. Tiré du Vol II. des Travaux de la 6e session du Congrès international des Orientalistes à Leide, par* J. P. N. Land. Mr. Land is a D.D., Professor of Mental Philosophy at Leyden, an Orientalist and a musician, and as his researches are the most recent, while he had access to all previous accounts, I follow him implicitly.

Land, I give all the notes that arose in different times in the two octaves, with the interval from the lowest note to the nearest cent. Professor Land, at my suggestion, gave them in equal Semitones to three places of decimals. On account of the notes in any string being a Fourth higher than those in the preceding, the two Octaves do not quite agree, and hence the cents are given for each, but are reduced by omitting the 1200 cents which would have to be added to each note in the second Octave. Of course it must be well

EARLIER NOTES ON THE ARABIC LUTE.

Notes.	First Octave.	Second Octave.	Cents.	
			1st Oct.	2nd Oct.
C	FIRST: open	THIRD: index	0	0
D fl	ancient near index	ancient middle	90	90
		Persian middle	..	99
	Persian near index		145	..
		Zalzal's middle	..	151
	Zalzal's near index		168	..
D	index	ring	204	204
E fl	ancient middle	little = FOURTH: open	294	294
	Persian middle		303	..
	Zalzal's middle		355	..
F fl		FOURTH: ancient near index	..	384
E	ring		408	..
		Persian near index	..	439
		Zalzal's near index	..	462
F	little = SECOND: open	index	498	498
G fl	SECOND: ancient near index	ancient middle	588	588
		Persian middle	..	597
	Persian near index		643	..
		Zalzal's middle	..	649
	Zalzal's near index		666	..
G	index	ring	702	702
A fl	ancient middle	little = FIFTH: open	792	792
	Persian middle		801	..
	Zalzal's middle		853	..
B ffl		FIFTH: ancient near index	..	882
A	ring		906	..
		Persian near index	..	937
		Zalzal's near index	..	960
B fl	little = THIRD: open		996	..
C fl	THIRD: ancient near index	FIFTH: ancient middle	1086	1086
		Persian middle	..	1095
	Persian near index		1141	..
		Zalzal's middle	..	1147
	Zalzal's near index		1164	..
C	index	ring	1200	1200

understood that all these divisions were not in use at the same period, but some at one and some at another, and that at all times the scales were made by selections from them. Two "near index" notes and some exceptional "middles" are omitted by Professor Land, as presenting no difficulties to those who take an interest in them.

It will be seen that each string is divided exactly like the first; that the cents on SECOND

are found by adding 498 to those on FIRST; those on THIRD 498 to those on SECOND (rejecting 1200 when we reach the second octave), those on FOURTH by adding 498 to those on THIRD, and those on FIFTH (which was Al Farabi's proposal) by adding 498 to those in FOURTH. There is one extra note not in the table, the "little" on FIFTH which is 90 (properly 2490) cents, but which was probably not used.

On observing the names of the notes in the above table they will be found to contain the following 14 forming Fourths up, as the Arabs considered them, or Fifths down, as we should say, *E A D G C F B*fl *E*fl *A*fl *D*fl *G*fl *C*fl *F*fl *B*ffl. But that these did not comprehend the Persian or Zalzal's "middle" upon any string, which refused to fit into this series of Fourths. This offended the systematic spirit of subsequent theorists, and we find, four centuries later, in the writings of Mahmoud of Shiraz (died A.D. 1315) and Abdulqadir, that they succeeded in replacing these Zalzal notes by adding three more Fourths proceeding from *B*ffl 882, contained in the former series, to *E* ffl 180, *A* ffl 678, *D* ffl 1176. The name of Zalzal was retained, but used for *F* fl 384 and *B* ffl 882, which already existed in the second octave (see table). Persian was used for *E*fl 294, and Persian and Zalzal "middle" were banished. The term "near" was used for "near the index" and made 180 instead of 145 and 168. While the "ancient near index" became the "remnant" 90, or what was left after going back two whole tones from the Fourth (498—408 = 90). The scale then became simply the later 17 division of the Octave.

No.	Notes.	First Octave.	Second Octave.	Cents.	
				1st Oct.	2nd Oct.
1	*C*	FIRST: open	THIRD: index	0	0
2	*D* fl	remnant	Persian	90	90
3	*E* ffl	near	Zalzal	180	180
4	*D*	index	ring	204	204
5	*E* fl	Persian	little	294	294
6	*F* fl	Zalzal	FOURTH: remnant	384	384
7	*E*	ring	....	408	..
			near *G* ffl	..	474
8	*F*	little	index	498	498
9	*G* fl	SECOND: remnant	Persian	588	588
10	*A* ffl	near	Zalzal	678	678
11	*G*	index	ring	702	702
12	*A* fl	Persian	little	792	792
13	*B* ffl	Zalzal	FIFTH: remnant	882	882
14	*A*	ring	....	906	..
			near *C* ffl	..	972
15	*B* fl	little	index	996	996
16	*C* fl	THIRD: remnant	Persian	1086	1086
17	*D* ffl	near	Zalzal	1176	1176
1'	*C*	index	ring	1200	1200

This, in fact, gives 19 notes, but *G* ffl 474 and *C* ffl 972 only found in the second octave, although they occur in this table, seem not to have been reckoned in. They do not form part of the scales. Without them the octave would be divided into 17, and with them into 19 unequal parts. But Villoteau supposes that the Arabs proceeded by intervals of the Third of an equal tone or $66\frac{2}{3}$ cents. It is not easy to see how he could have muddled himself to such an extent. That he was quite wrong appears from the above table arranged from Professor Land's. The interval between any two notes in the same octave is either 90 or 24 cents, that is, the Pythagorean *limma* or *comma*. But in going from *E* in the first to *G* ffl in the

second octave, and also from *A* in the first to *C* ffl on the second, we do get intervals of 1266 cents, which is in fact an Octave and one-third of a Tone. This, however, is the only approach to a division by thirds of a Tone, and even for this purpose two tones have to be used which the Arabs ignored in their scales. Hence Professor Land has quite disproved this erroneous conception of thirds of Tones.

Now this large collection of notes was of course not used as a single scale, but, like our own 12 semitones, as a fund out of which scales might be formed by selection. And the following are the 12 historical scales reported by the Arabian systematists as described by Prof. Land. But I have here given the letter names to the notes which are used in the above list (the Arabic names have no connection with them) and added the cents both between the notes, and from the lowest note. The orthography adopted by Professor Land for the names of the *maqamat* or scales is French.

THE TWELVE ARABIC SCALES.

1. *'Ochaq—C* 204 *D* 204 *E* 90 *F* 204 *G* 204
0 204 408 498 702
A 90 *B* fl 204 *C*.
906 996 1200.

2. *Nawa— C* 204 *D* 90 *E* fl 204 *F* 204 *G*
0 204 294 498 702
204 *A* 90 *B* fl 204 *C*.
906 996 1200.

3. *Bousilik —C* 90 *D* fl 204 *E* fl 204 *F* 90 *G* fl
0 90 294 498 588
204 *A* fl 204 *B* fl 204 *C*.
792 996 1200.

4. *Rast— C* 204 *D* 180 *F* ffl 114 *F* 204 *G* 180
0 204 384 498 702
B ffl 114 *B* fl 204 *C*.
882 996 1200.

5. *'Iraq— C* 180 *E* ffl 204 *F* fl 114 *F* 180 *A* ffl
0 180 384 498 678
204 *B* ffl 114 *B* fl 180 *D* ffl 24 *C*.
882 996 1176 1200.

(There are eight tones to this scale, because there are two forms of *C*, namely *B* ffl and *C*, differing from each other by a Pythagorean comma, but these two forms were probably not played in succession, but were alternated, just as the major or minor Seventh, and the major or minor Sixth in our own minor scale, which, if these were included, would be made to have 9 tones. The grave Second in our just major scale would have been a more apt illustration, had it not been lost in tempered music.)

6. *Isfahan — C* 180 *E* ffl 204 *F* fl 114 *F* 204 *G*
0 180 384 498 702
180 *B* ffl 114 *B* fl 180 *D* ffl 24 *C*.
882 996 1176 1200.
(Another eight tone scale, see remarks on last.)

7. *Zirafkend— C* 180 *E* ffl 114 *E* fl 204 *F* 180
0 180 294 498
A ffl 114 *A* fl 90 *B* ffl 204 *C* fl 114 *C*.
678 792 882 1086 1200.
(Eight notes, four intervals semitones.)

8. *Bouzourk—C* 180 E ffl 204 *F* fl 114 *F* 180 *A* ffl
0 180 384 498 678
24 *G* 204 *A* 180 *C* fl 114 *C* (eight tones).
702 906 1086 1200.

9. *Zenkouleh—C* 204 *D* 180 *F* fl 114 *F* 180 *A* ffl
0 204 380 498 678
204 *B* ffl 114 *B* fl 204 *C*.
882 996 1200.

10. *Rahawi—C* 180 *E* ffl 204 *F* fl 114 *F* 180
0 180 384 498
A ffl 114 *A* fl 204 *B* fl 204 *C*.
678 792 996 1200.

11. *Hhosaïni—C* 180 *E* ffl 114 *E* fl 204 *F* 180
0 180 294 498
A ffl 228 *A* 90 *B* fl 204 *C*.
678 906 996 1200.

12. *Hhidjazi—C* 180 *E* ffl 114 *E* fl 204 *F* 180
0 180 294 498
A ffl 204 *B* ffl 114 *B* fl 204 *C*.
678 882 996 1200.

Suppose we begin this last scale on *B* fl, it would become *B* fl 204 *C* 180 *E* ffl 114 *E* fl 204 *F* 180 *A* ffl 204 *B* ffl 114 *B* fl, where the intervals 182, 114 cents differ only by 2 cents each from 182, 112, which would occur in our just scale of *B* fl, which is *B* fl 204 *C* 182 *D* 112 E fl 204 *F* 182 *G* 204 *A* 112 *B* fl. Now this difference is imperceptible even in chords, and this 12th scale could therefore be used for harmony even better than our usual equally tempered scale. Yet the Arabs never used harmony at all, and were probably quite unaware of this property of their scale, which was pointed out by Professor Helmholtz.

Zalzal's intervals of 355 and 853 cents, although effectually banished from classical music during our middle ages by this new scale of 17 (or 19) unequal divisions, was evidently too deeply rooted in popular feeling to be really lost. Eli Smith, an American missionary at Damascus, having been forced to study the Arabic musical system in order to make the children sing in his mission schools, as they could not be taught the European intervals, fortunately became ac-

quainted with Michael Meshaqah, a very intelligent man, a mathematician and a musician, who had written a treatise on Arabic music. This treatise Eli Smith translated in an abridged form and published at Boston, U.S. America, in 1849, in the *Journal of the American Oriental Society* (vol. 1, pp. 171—217, with a plate). It shows that Meshaqah adopted an equal temperament of 24 Quartertones, or 24 equal divisions of the octave, each containing 50 cents, and that in this he considered the following as the normal scale, which might begin upon any one of the Quartertones—

I	200	II	150	III	150	IV	200	V	150	VI	150	
0		200		350		500		700		850		
						VII	200	I'				
						1000		1200				

Comparing Zalzal's—

I	204	II	151	III	143	IV	204	V	151	VI	143	
0		204		355		498		702		853		
						VII	204	I'				
						996		1200				

we find a practical identity, showing that Meshaqah's scale is a pure survival of Zalzal's. It appears, however, from the following specimens of 95 Arabic melodies given by Eli Smith, that one or more of the notes were frequently sharpened or flattened by a Quartertone or 50 cents, giving intervals with different characters. He has engraved 11 of these so-called melodies, without any indication of time or rhythm, in a peculiar notation for which we may substitute a simple modification of ordinary notation, using *q* (or in music notation the inverted sign for *flat*) read *quarter*, to signify "sharpened by a quarter of an equally tempered tone." Taking the first note of the scale as *A*, the normal scale throughout two octaves, with the name of each note in Arabic (as Eli Smith writes them, omitting diacritical signs) will be—*A* yegah, *B* osheiran, *C*q araq, *D* rest, *E* dugah, *F*q sigah, *G* jehargah, *a* nawa, *b* huseiny, *c*q auj, *d* mahur, *e* muhhaigar, *f*q buzrek, *g* mahuran, *á* remel-tuty.

Each Quartertone has also its peculiar name throughout two octaves, and by means of them the following melodi s were written in the original Arabic treatise, here translated as above.

The scales subjoined have been collected from the melodies, and give every note in each melody independent of octave. Of course every note in a scale does not occur in every melody. There is no notion of a tonic, but Eli Smith calls the *final* (to use a medieval term for the last note of a melody) the "keynote," and hence I have arranged the scale from and to the final in each case. Though the melodies are "free," that is, not fixed in rhythm or length, some notes in some melodies are marked as "distinct" (to these I have added an acute accent), and others as "glanced at, obscure, highly touched" (to these I have added the mark of degree °), of which Eli Smith says he does not fully understand the technical meaning. However, it cannot be far from *forte* and *piano*, or accented and unaccented, or long and very short.

Arabic Melodies from Meshaqah.

[Capitals indicate the lower, small letters the upper octave.]

1. *Shed Araban.—a b*fl *a d d*fl *b*fl *a e f e d d*fl *b*fl *a G F E D D*fl *B A*. [Scale, *A* 100 *B*fl 100 *B* 200 *D*fl 100 *D* 200 *E* 100 *F* 200 *G* 200 *a*, in which there is no note not in our equally tempered scale.]
2. *Araq.—a G F*q *E D C*q. [This is portion of the normal scale descending from *a* to *C*q.]
3. *Araq Zemzemy.—C*q *D E a G F*q *E D C*q *F*q' *e c*° *a G F*q *E F*q *E D C*q *B A D F*q *a G F*q *E*. [Scale, *A* 200 *B* 100 *C* 50 *C*q 150 *D* 200 *E* 150 *F*q 150 *G* 200 *a'*. This lightly touched *c*° is possibly mere grace note.]
4. *Rahhat el Arwahh.—a a*fl *a*fl *E F E D F E D C*q. [Scale, *A* 350 *C*q 1,0 *D* 200 *E* 100 *F* 300 *A* fl 100 *a'*.]
5. *Remel.—a G G a a*fl *b*° *a G G G*flq *G a*° *F*q' *F E D C*q. [Scale, *A* 200 *B* 150 *C*q 150 *D* 200 *E* 150 *F*q 100 *G*flq 50 *G* 100 *A* fl 100 *a*. The *G*flq is a mere grace note, and probably *G*fl would do as well.]
6. *Nikriz.—a a*fl *F*q' *b a' a* fl *F*q *E D*. [Scale *A* 200 *B* 300 *D* 200 *E* 150 *F*q 250 *A*fl 100 *z*.]
7. *Nishawerk.—a' a*fl *G*fl *E D*. [Scale *A* 500 *D* 200 *E* 200 *G*fl 200 *A* fl 100 *a*.]
8. *Penjgah.—a' a*fl *G*fl' *a*fl *a e*q' *b' a' a*fl *G*fl' *G' F*q *E D*. [Scale, *A* 200 *B* 150 *C*q 150 *D* 200 *E* 150 *F*q 50 *G*fl 100 *G* 100 *A* fl 100 *a*.]
9. *Sadhkar el muta'arif.—D E G*fl' *E D a' b' a G G*fl *E' B C*q *D*. [Scale, *A* 200 *B* 150 *C*q 150 *D* 200 *E* 200 *G*fl 100 *G* 200 *a*]
10. *Hhejaskar,—E b c b a a*fl *F*q *E B E*. [Scale, *A* 200 *B* 100 *C* 400 *E* 150 *F*q 250 *A* fl 100 *a*]
11. *Shawerk of the Egyptians.—a' G*° *F*q' *E' D C*. [Scale, *A* 300 *C* 200 *D* 200 *E* 150 *F*q 150 *G* 200 *a*.]

In these 11 melodies there is only one, No. 2, which contains the notes of the normal scale, *A B C*q *D E F*q *G a*, unaltered. On looking

through the whole of the 95 melodies I find only 6 others with unvaried notes. These are

12. *Mukhalif arak.*—*C*q *D E G F*q *E D C*q.
13. *Rest.*—*D E F*q *G a G E D A D.*
14. *Ssuba called Rekb.*—*G' b*° *G F*q *E.*
15. *Sigah.*—*F*q *D F*q *a d c*q *b a G F*q.
16. *Bestniker.*—*c*q *d c*q *b a' d c*q *b a G F*q.
17. *Nejdy-Sigah.*—*F*q *G a b c*q *b a b c*q *d c*q *b a G F*q.

These scales and melodies introduce two entirely new points, unknown in European and common in Oriental music. First, the series of "neutral" intervals, intermediate in position and character between the European, and hence bearing a neutral stamp, so that the European ear does not know how to appreciate them. They have consequently led musicians into many errors in attempting to record them. Thus, 250 cents is neutral between a Tone 200 (just 204) and a minor Third 300 (just 316). Again, 350 cents (more accurately Zalzal's 355) lies on the boundary between the appreciation of a minor Third 300 (just 316), and a major Third 400 (just 386). The experiment is easily tried on the Dichord. At 355 cents Mr. Hipkins could not say to which Third the character of the interval approached. It was purely neutral. Observe that 350 cents is half a Fifth 700 (just 702), and the succession of 0 350 700 rapidly becomes pleasing to the ear. The interval 450 cents lies between a major Third 400 and a Fourth 500 (just 386 and 498), and is rather appreciated as a very flat Fourth. All these ambiguities are repeated a Fourth higher. Thus, 850 cents (between a minor Sixth 800, and a major Sixth 900) is precisely analogous to 350 cents, and (as 853 cents) forms part of Zalzal's scale. Observe that these intervals have no harmonic value or meaning. They could not exist in any system of music which recognised chords. Chords were an entirely European medieval discovery, of which Greece and Asia are still totally ignorant. Observe also that a solo player on a stringed instrument without frets, who is absolutely unchecked by harmony, is able to amuse himself by taking all manner of strange intervals, or occasional variations of established intervals. And this leads to the second point, the constant alteration of the normal notes in the scale, nominally by a Quarter-tone, really most probably by some indefinite but small interval at the pleasure of the performer, who consulted only his own ear at the moment, and could scarcely be checked by the ears of an audience. But these variations were reduced to a system, at least on paper, and Meshaqah is strong on "the principles and details of his *science*" of music.

(2.) *The Highland Bagpipe.*—It will seem strange to introduce this instrument among the Arabian. But the bagpipe is found sculptured at Nineveh. It was possibly brought to Europe during the Crusades, long after the deaths of Zalzal and Al Farabi, but before the introduction of the Arabic scale of 17 (or 19) notes to the octave. And it seems originally to have had that Zalzal scale already noted, viz.:—

I	204	II	151	III	143	IV	204	V	151	VI	143
0		204		355		498		702		853	
V	204	VI									
996		1200									

Of which the tempered representative is the principal scale of Meshaqah just discussed. Of course, there must have been some alterations, but this Damascus scale of Meshaqah would represent the scale sufficiently well for all purposes. The Highland bagpipe has at present only nine notes, written *g' a' b' c'' d'' e'' f'' g'' a''* (*g'* being on the second line of the treble staff), and also two *drones* or deep notes which are always sounding (being the first and second octave below *a'*, that is, on the top line and bottom space of the bass staff). Now it is generally said that *g'* to *a'* is not quite a tone, and that *c'' f''* are not exactly *c''* and *f''*, or *c''* sh and *f''* sh of the ordinary notation, but in each case some intermediate sound, the consequence being that the bagpipe cannot play with any other instrument in a band, and two or more bagpipes can only play in unison. The instrument is a kind of oboe played with a bellows instead of the mouth. To determine what this scale really was, Mr. C. Keene, the well-known artist of *Punch*, who is a performer on the bagpipe, kindly brought his instrument to my house and played through the scale, while Mr. Hipkins determined the pitch by my forks. The following was the result. The first line gives the number of vibrations, the second line gives the names of the notes and the interval in cents between them, the third line gives the intervals in cents from the lowest *a'*, omitting the low *g'* which is repeated in the octave as *g''*.

Observed Scale of the Bagpipe.

Obs. vib.—	395		441		494		537		587
Notes.—	*g'*	191	*a'*	197	*b'*	144	*c''*	154	*d''*	208
Cents.—			0		197		341		495

Obs. vib.—662 722 790 882
Notes.— e'' 150 f'' 156 g'' 191 d''
Cents.—703 853 1009 1200

This scale took us quite by surprise, and we immediately wrote to Mr. Glen, the great bagpipe seller, to make inquiry. He informed us that "the scale as regards intervals has never been altered. If the chaunter [the oboe played on] you had is one of McDonald's [it was so] or our own, it was no doubt correct. Our opinion is that if a chaunter was made perfect in any one scale it would not go well with the drones. Also there could not be nearly so much music produced (if you take into consideration that it has only 9 invariable notes), as at present it adapts itself to the keys of *A* [major], *D* [major], *B* minor, *G* major, *E* minor, and *A* minor. Of course we do not mean that it has all the intervals necessary to form scales in all those keys, but that we find it playing tunes that are in one or other of them."

Now the equal temperament of the scale just deduced would be clearly 0 200 350 500 700 850 1000 1200, or precisely the normal Damascus lute scale, just considered. For comparison, I determined the number of vibrations in such a scale, and also for Zalzal's taking the same a', with this result—

Notes	a'	b'	c''	d''	e''	f''	g''	a'
Observed vib.	441	494	537	587	662	722	790	882,
Damascus vib.	441	495	540	587	661	721	786	882
Zalzal's vib...	441	496	541	587	661	722	783	882

Mr. Keene's chaunter was not perfect (none is), and the blowing (which was difficult, as wind had to be got up in the bag for each separate note), could not be absolutely relied on. Clearly c'' was a little flat, and g'' a little sharp, the latter designedly, because the custom is to make the interval $g'' : a''$ less than 8 : 9 or a whole tone, which is an accommodation to the major scale of *A*, and is evidently a modernism. Mr. Colin Brown (Euing Lecturer on the Science, Theory and History of Music at Anderson's College, Glasgow), informs me, after diligent inquiry, that there is no scientific principle adopted in boring the holes of the chaunters, and that only about one in six made turns out useful. He himself thinks the bagpipe ought to play the major scale *A*. I should recommend reverting to Zalzal's scale, either in the pure or tempered form. In the pure form the ratios are $a' : b' = d'' : e'' = g'' : a'' = 8 : 9$, $b' : c'' = e'' \cdot f'' = 11 : 12$, $a' : d'' = 3 : 4$, $a' : e'' = 2 : 3$. There is, therefore, only one unfamiliar interval 11 : 12 = 151 cents, and that occurs on the trumpet. From these ratios Zalzal's vibrations were calculated above. Of course in this case *c* q and *f* q should in theoretical writing take the place of *c* and *f*.

(3.) *Northern Tambour, or that of Khorassan.*—A guitar with a circular or oval body, and a very long neck on which (formerly) the frets extending to a Ninth were placed. Of these 5 were fixed, representing the Second 204, Fourth 498, Fifth 702, Octave 1200 and Ninth 1404 cents, of the open string. The other 13 were movable, so that they could be adjusted for the different scales or *maqamat*, following the plan of the 12 scales already given. Referring to the table of the later 17 division, the notes of the tambour and lute coincided as far as 588 cents, then in place of the lute's 678 cents (our *A* ffl), the tambour had 612 cents or 498 + 114 cents (our *F* sh). Then tambour and lute again coincided till the lute's 882 *B* ffl which the tambour replaced by 816 or 702 + 114 cents our *G* sh, and then again the two coincided up to 996 *B* fl, but the remaining intervals, 1020 *A* sh, 1110 *B* and 1224 *B* sh, were different. The scale was then as follows, (*) marking the fixed, and (†) auxiliary tones :—

C *D* fl *E* ffl **D* *E* fl *F* fl *E* **F* *G* fl *F* sh **G*
0 90 180 204 294 384 408 498 588 612 702
†*A* fl *G* sh *A* *B* fl †*A* sh *B* **C* *B* sh
792 816 906 996 1020 1110 1200 1224
C sh **D*.
1314 1404.

Instead, therefore, of taking Fourths up from *B* to *D* ffl, this scale formed the series from *B* sh to *E* ffl, with the exception of four, marked by being inclosed in ( ) in the following list, where the subscribed numbers give the cents from *C*, subtracting 1200 where needed.

B sh *E* sh *A* sh (*D* sh) *G* sh *C* sh *F* sh *B* *E*
1224 522 1020 (318) 816 114 612 1110 408
A *D* *G* *C* *F* *B* fl *E* fl *A* fl *D* fl *G* fl (*C* fl)
906 204 702 0 498 996 294 792 90 588 (1086)
F fl (*B* ffl) *E* ffl.
384 (882) 180.

Al Farabi gives the means of tuning two strings out of the three occasionally used: first, with the strings in unison; secondly, with an interval of 228 cents, or two apotomes of 114 cents between them; thirdly, with the interval of a major Tone, 204 cents; fourthly, with the interval of a Pythagorean minor

Third, 294 cents; and fifthly, with the interval of a Fourth, 498 cents.

(4.) *Al Farabi's Flutes or Oboes.*—Professor Land calls them flutes, but his figures show that they were played with a double reed like the oboe. These were intended to play in Zalzal's scale—

0	204	355	498	702	853	996	1,200 cents,
a	*b*	*c*q	*d*	*e*	*f*q	*g*	*a'*

but the Third and Sixth varied. A double flute, figured by Professor Land from a Madrid MS. gives 9 notes, just as on the bagpipe, but having the Persian 303 and 801 cents, which are 52 cents lower than Zalzal's, thus (giving the nearly equally tempered notes written below, – 204 means an interval of 204 cents downwards)—

– 204	0	204	304	498	702	801	996	1,200.
G	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*a'*

This gives the tempered form of our descending *A* minor played upwards.

(5.) *The Rabab.*—This was a two-stringed viol played with a bow. The one Professor Land figures has a finger board, the one I saw had none. It was supposed to be the custom to stop at $\frac{8}{9}$, $\frac{5}{6}$, $\frac{64}{81}$, and $\frac{32}{45}$, the lengths of the string, that is, 0 204 316 408 590 cents, or at a major Tone, minor Third, Pythagorean major Third, and Tritone, but player was really guided by ear only. It is believed, but not certain, that the two strings were stopped in the same way. Usually the interval between the strings was a minor Third 316 cents; but it was sometimes a (Pythagorean) major Third 408 cents, and sometimes a Tritone 590 cents.

This gives three scales which may be written thus, I being the open string:—

	I	204 II	112 III	92 IV	82 V
First string	0	204	316	408	590
Second string .	316	520	632	724	906
Or else	408	612	724	816	998
Or else	590	794	906	998	1180
Or say—					
First string	*C*	*D*	*E* fl	*E*	*F* sh
Second string ..	*E* fl	*F*	*G* fl	*G*	*A*
Or else	*E*	*F* sh	*G*	*G* sh	*A* sh
Or else	*F* sh	*G* sh	*A*	*A* sh	*B* sh

This gave the sharp Tetrachord *C* to *F* 520 cents, and the exact Tetrachord *E* to *A* 498 cents. But the consequent scales are not clear.

(6.) *The Southern Tambour or that of Bagdad.*—This was long-necked and two-stringed, and was used in Bagdad and to the west and south of that city. We may consider that the string was divided into 40 parts, of which only 5 were used for stopping or fretting, and the higher string was tuned in unison with the highest note on the lower string. This gave the following arrangement:—

Vib. lengths	40	39	38	37	36	35 parts.
	I	II	III	IV	V	VI
Lower string	0	44	89	135	182	231 cents.
Second string	231	275	320	366	413	462 ,,

This is a scale entirely without parallel; but Prof Land conjectures that a process of this kind may have led to the first scale of the Persian lute before Pythagorean intonation was invented. The principle is that equal divisions of the difference of two lengths of a string will give nearly equal intervals extending from one to the other. In the present case, these intervals are 44, 45, 46, 47 and 49 cents, of which the three first at least do not differ perceptibly. Then he supposes that the string may have been divided into 20 parts, and 5 of them taken; this would give—

						Parts.
Vib. lengths	20	19	18	17	16	15
	I 89	II 93	III 99	IV 105	V 112	VI
						Cents.
Sums	9	89	182	281	386	498
or say	*C*	*D* fl	*D*	*E* fl	*E*	*F*

Where *D* fl is properly 90 cents, *E* fl 281 is half a comma less than the Pythagorean *E* fl 294, and the others are exact. The alteration into Al Farabi's intervals

0	90	204	294	408	498
or *C*	*D* fl	*D*	*E* fl	*E*	*F*

does not, in any case, amount to more than a comma (22 cents).

The mode in which the Persian and afterwards Zalzal's "middle finger" was obtained, by halving the distance between the frets, shows that this plan is in accordance with the habits of the people. Compare also the 9 and 13 division in the modern Bengali string in the next section.

VII.—India.

Rajah Sourindro Mohun Tagore, president of the Bengal Academy of Music, in 1875, collected and printed "for private circulation only" a number of papers and brief treatises on Hindu music by Captain N. A. Willard, Sir William Jones, Sir W. Ouseley, J. D. Paterson, Francis

Fowke and others, kindly lent me by Mr. W. S. W. Vaux, F.R.S. In 1884, he published "The Musical Scales of the Hindus," pp. 118, kindly lent me by M. Victor Mahillon, of the Conservatoire, Brussels, the only English modern native authoritative work on Indian music extant.

H.H. the Rajah Ram Pal Singh, kindly brought to me his *Sitahr*, or long-necked guitar, which has movable frets. These he set in succession for different modelets that he played to Mr. Hipkins and myself, and by registering the position of the frets after each setting, we were enabled afterwards to take the pitch of each note employed, and thus, for the first time, to determine an Indian scale as actually tuned and used by a native musician. I beg to express my great obligations to His Highness for his courtesy.

In Rajah S. M. Tagore's last book, which is my chief authority, there is a table, "by a European friend," of the frets for the primitive Indian *C*-scale compared with the European just scale and the modern Bengali division of the string. These divisions are made on the supposition that the vibrations are inversely as the lengths of the strings, which all my observations and experiments show is not the case on any practical instrument. The same measurements are given in the *Annuaire du Conservatoire* de Bruxelles, 1878, pp. 161-169, to which they were communicated by the Rajah. As this is the only attempt at measuring an Indian scale that I have met with, I give it here in a reduced form. The wire is supposed to consist of 180 parts.

Old *C*-Scale.

Vib. lengths.—180 160 144 135 120
Notes.— *C* 204 *D* 182 *E* 112 *F* 204 *G* 204
Sums.— 0 204 386 498 702
Vib. lengths.—106⅔ 96 90
Notes.— *A* 182 *B* 112 C
Sums.— 906 1088 1200

The modern Bengali divisions will be given afterwards.

Scale is the translation of the word defined as "a series of notes arranged according to certain rules." And the seven notes of the scale are translated as above, using the letters *C*, *D*, &c., rather laxly. These form a *septime*, which corresponds to our Octave, but it ended on the seventh note. Only 3 septimes are in use. Degrees are defined as "subdivisions of sound intervening [between] the notes." There are 22 such in the Octave. but what their precise value may be does not appear.

The Rajah gives the following as the three scales recognised by the ancient authorities, with the number of degrees in each interval, here marked by points above, the note being in olden time considered to be at the end of the interval, though in more modern times it is placed at its beginning.

C-Scale.

No.	4	7	9	13	17	20	22
Degrees	. . . .						
Notes	*C*	*D*	*E*	*F*	*G*	*A*	*B*

F-Scale.

No.	4	7	9	13	16	20	22
Degrees	. . . .						
Notes	*C*	*D*	*E*	*F*	*G*	*A*	*B*

E-Scale.

No.	1	4	6	10	13	16	19
Degrees	. . . .						
Notes	*B*	*C*	*D*	*E*	*F*	*G*	*A*

These seven notes are divided into two classes, which may be translated, *fixed* and *changing*: The fixed notes have their values as in the *C*-scale. A changing note is one of the fixed altered by one, two, or three degrees. There are 7 fixed and 12 changing notes, but I have failed to interpret the ancient distribution of the latter among the former. The modern musicians obtain the changing notes by making *D*, *E*, *F*, *A*, and *B*, "flat or very flat, sharp or very sharp," terms of which the only explanation given is by the 22 degrees, as follows:—

Fixed.

No.	1	5	8	10	14	18	21
Degrees	. . . .						
Notes	*C*	*D*	*E*	*F*	*G*	*A*	*B*

Changing.

No.	2	3	6	7	9	12	13	15	16	19	20	22
Degrees	. . . .											
Notes	*D*	*D*	*E*	*E*	*E*	*F*	*F*	*A*	*A*	*B*	*B*	*B*

This arrangement would seem to imply that *D* depressed two degrees is "flat," and three degrees "very flat" (which we may write by the sign for double flat), the first corresponding roughly to a Semitone, the second to a Semitone and a half. But *E* may be depressed one or two degrees, or raised by one, written *E* ffl, *E* fl, *E*, *E* sh, the "sharp" being now only one degree. *F*, on the other hand, may be raised two (sharp) or three (very sharp) degrees, written *F*, *F* sh, *F* ssh. *A* may be

depressed two or three degrees, and *B*, like *E*, may not only be depressed one or two degrees, but raised one degree. *C* and *G* remain unaltered as the backbone of the scale. Now, we do not know precisely what a degree is, and hence any representation of these differences with exactness is impossible. But we may obtain a tolerably approximate notion thus:—Suppose the fixed notes to have been those already described in the old *C*-scale, so that *C* to *D*, *F* to *G*, and *G* to *A*, have each 204 cents, and a degree of such an interval should be a quarter of that amount, or 51 cents. The interval *D* to *E*, or *A* to *B*, has only 182 cents, and but only 3 degrees, so that each degree has $60\frac{2}{3}$ cents. Finally, the interval *E* to *F*, or *B* to *C* has 112 cents, and only two degrees, hence one of these degrees has 56 cents. The modern Bengali division gets over the difficulty thus:—The *C*-string is divided in half, giving the Octave; the half nearest the nut is again halved, giving the Fourth *F*. The part between the nut and *F* is divided into 9 equal parts, each giving one degree; and the other part, from *F* to the Octave, is divided into 13 equal parts, each giving a degree. From these indications it is possible to calculate the value of each degree and assign the notes. In the following table I give the number of degrees and the calculation of their value on both plans, *old* and *new*, with the names of the 19 Indian notes, assuming that pitch varies inversely as the length of the string, as shown by the position of *F* and the Octave, and that any errors thus arising have been corrected by ear.

INDIAN CHROMATIC SCALES.

Degrees..	1	2	3	4	5	6	7	8
Notes....	*C*	*D* ffl	*D* fl	—	*D*	*E* ffl	*E* fl	*E*
Old	0	51	102	153	204	$264\frac{2}{3}$	$325\frac{1}{3}$	386
New	0	49	99	151	204	259	316	374
Degrees..	9	10	11	12	13	14	15	
Notes....	*E* sh	*F*	—	*F* sh	*F* ssh	*G*	*A* ffl	
Old	442	498	549	600	651	702	753	
New	435	498	543	589	637	685	736	
Degrees..	16	17	18	19	20	21	22	
Notes....	*A* fl	—	*A*	*B* ffl	*B* fl	*B*	*B* sh	
Old	804	855	906	$966\frac{2}{3}$	$1027\frac{1}{3}$	1088	1144	
New	787	841	896	952	1011	1070	1135	

The only values agreeing in each are *C*, *D*, *F*, while new *E* fl is the just minor Third, a mere accident. The 9 degrees from *C* to *F* vary from 49 to 63 cents, and then there is a sudden break, after which the 13 degrees from *F* to the Octave vary from 45 to 65 cents. This is the first intelligible presentment of the Indian scale which I have been able to effect. It will be seen that *C D* fl *D E* fl *E F F* sh *G A* fl *A B* fl *B* are represented pretty well by our equally tempered notes, but that the 7 intermediate notes *D* ffl *E* ffl *E* sh *F* ssh *A* ffl *B* ffl *B* sh could only be tempered on the Quartertone system used in Syria. Hence, in the usual transcription, these 7 notes are identified with some of the others, possibly *D* ffl with *D* fl (not with *C*), *E* ffl with *E* fl (not with *D*), *E* sh with (as usual), *F* ssh with *F* sh (not with *G*), *A* ffl with *A* fl (not with *G*), *B* ffl with *B* fl (not with *A*), and *B* sh with *C* (as usual). These confusions necessarily injure the original character of the music, and give it a harmonisable appearance which is entirely foreign to Indian music.

We may now understand how on the *Vina* or native classical Indian instrument, which has frets from 7-8ths to 9-8ths of an inch high, it is considered sufficient to use 12 frets to the Octave, giving approximately our 12 Semitones (see the account of the "Vina of Madras" below), and to leave them to be corrected and the 7 Quartertones to be produced when wanted, by pressing on the string behind the fixed frets, by which an increase of tension is obtained, easily raising the pitch by a quarter of a Tone. Thus, on a *Vina*, lent by Mr. Chappell to the South Kensington Museum, Mr. Hipkins and I raised the note of fret 5 from 300 to 316 vib., or 90 cents, and that from fret 17 by much harder pressure from 539 to 573 vib., or 106 cents. On the modern Indian long-necked guitar, or *Sitahr*, which has superseded the *Vina*, the moveable frets are disposed at first so as to suit the tune for most of the half and quarter Tones, and the occasional elevation by a degree is produced by deflecting the string, drawing the finger along the fret, for which ample room is left on the fingerboard. This deflection we witnessed when Rajah Ram Pal Singh played to us, and, measuring the amount of deflection, we found that it produced an interval of 48 cents, or, say, one degree.

The number of different scales produced by selecting some of these 19 notes is very large. Rajah S. M. Tagore enumerates 32 with 7 notes each, 112 with 6 notes each, and 160 with 5 notes each, or 304 in all; but as in figuring these scales he has neglected to mark what notes were "very sharp" or "very flat," it would be useless to cite them.

These scales are of course used to produce airs. A *mode* is, according to the Rajah,

"the succession of notes so arranged, according to prescribed rules, as to awake a certain feeling of the mind." In such modes four classes of notes are distinguished:—(1.) The *ruler*, "which by the frequency of its application in a certain mode, and by the length of its duration, shews to the best advantage the character and the living form, as it were, of that mode; hence it is called the *king*, that is, principal note, and by Hindust'hani musicians the life and soul of the mode." It clearly answers to the European tonic, but it does not bear to the others exactly the same relation, as Indian music seems devoid of tonality in the European sense. (2.) The *minister*, "any note lying at an interval of 8 or 12 degrees from the ruler . . . . . when, for instance, *C* is the ruler, *F* and *G* are its ministers," hence these answer to our dominant and sub-dominant. (3.) The *enemy*, the admission of which would destroy the character of the mode. (4.) The *subordinates*, the remaining notes. There are four parts or strains to each mode; and the modes are of three kinds, according as they contain 7, 6 or 5 notes, and each of these, again, are divided into three kinds, according as they are *pure* (having the characters of one mode only), *dual* (partaking of the nature of two modes artistically blended), and *mixed* (of three or more modes). The six original modes are the only instances of the pure class, and are called modes proper; the mixtures are called either modes or modelets, that is wives of the modes. It would be as impossible to go into details as into European counterpoint, but so much belongs to the scale proper. The Rajah says of harmony: "The spirit of Indian music is against the adoption of harmony in its European sense. The mode is essentially melodic in its character—it is a succession of notes artistically so arranged as to produce a certain effect, differing in the minutest particulars from that derivable from another mode."*

Now I turn to the investigations of Mr. Hipkins and myself with Rajah Ram Pal Singh. The setting of the frets was a pure matter of ear and memory. The frets were moved somewhat hastily, and perhaps were not arranged with the accuracy that would have been attained by a professional musician. Then the Rajah having played an air, I measured the position of the frets, and was thus able to put them in the same position at any time, Then the position of the frets was changed, and another air was played, and the places of the frets again recorded. In this way on one visit the Rajah changed the position of the frets three times, and at another twice, so that we obtained 5 scales, of which apparently the first and fourth, set on different days, were meant for the same. The finger-board of the Sitahr is 27 inches long and of uniform width of $3\frac{3}{4}$ inches, so that the frets can be shifted to any extent, except in so far as they are stopped by the supports of the "sympathetic" strings, namely, those which are themselves not played on but vibrate in unison with certain notes that are played. This Sitahr had 16 movable frets. The two highest and five lowest were only used when it was necessary to run into another Octave, the main part of the air being on the middle 9 frets, of which however one was always unused. The air was played on one string only, though there are 4 other strings tuned to a Tone, a minor Third and a Fourth above, and a Fifth below the speaking string. These seemed to be occasionally struck, but not to produce harmony, and they were not used with the frets. The

* In giving the foregoing account, I have translated all the terms for the convenience of the English reader. I now append the Indian words, using ah a (in China, *u* in hut), ee i, oo u (in p*u*t), *e o* (in *there*, *note*), *ai*, *au* (as in *eye*, *how*) for the vowels, *ch sh* as in *chin*, *shot*, the small capitals for cerebrals, spoken with a reverted tongue, and *'h* for an *h* introduced after a consonant; *s'* is now pronounced *s*, but was once the palatal German *ch* in *ich*:—

Scale, *grahma*.
Septime, *s'aptaka*.
Degree, *s'ruti*.
C, *sharja* or *sa*.
D, *rishab'ha* or *ri*.
E, *gahnd'hahra* or *ga*.
F, *mad'hyama* or *ma*.
G, *panchama* or *pa*.
A, *d'haivate* or *d'ha*.
B, *nishahda* or *ni*.
C-scale, *sharja grahma*.
F-scale, *mad'hyama grahma*.
E-scale, *gahnd'hahra grahma*.
Fixed, *prakrita* or *s'udd'ha*.
Changing, *vikrita*.
Sharp tones, *tibra-suras*, the sign for them *patahkah*.
Flat tones, *komala-suras*, the sign for them *trikona*.
Very sharp, *ati-tibra*.
Very flat, *ati-komala*.
Mode, *rahga*.
Modelet, *rahginee*.
Ruler, *vahdee*.
King, *rahjah*.
Life and soul, *jahn*.
Minister, *samvahdee*.
Enemy, *vivahde*.
Subordinate, *anuvahdee*.
Seven-note scale, *sampoorna t'haht*.
Six-note scale, *shahrava t'haht*.
Five-note scale, *orava t'haht*.
Pure (mode), *s'udd'ha*.
Dual (mode), *ch'hahyahlaga* or *sahlanka*.
Mixed (mode), *sankeerna*.

scale began on the Sixth fret, forming about a Fifth with the open string, which gave *E* fl 156 vib.; but the string, being an English pianoforte wire, was much too thick, and hence the pitch must not be insisted on. It is only the intervals played with which we are concerned.

In the following arrangement, I give the cents observed for each setting, the first and and fourth being, for convenience of comparison, placed immediately under one another. Then, in the next line, I give the cents in the nearest note of the *new* scale, already cited, because that must have been the one intended, though the notes played, even the Fourth and Octave, often differed from those in that scale by a comma, or even more (as for the undoubted Fourth and Octave), at which we cannot be surprised under the circumstances. Then follow the names of the corresponding notes. Accepting these, it would appear that Rajah Ram Pal Singh, for the first and fourth setting, used the notes in Rajah S. M. Tagore's 1st seven-note scale; for the second setting (supposing *E* ffl to be identified with *E* fl in the notation of those scales), the 13th; for the third setting, the 29th; and for the fifth setting, the 9th; so that all the scales are identified.

Scales set by Rajah Ram Pal Singh.

First and Fourth Setting:—

Obs. 1st ..	0	183	342	533	685	871	1074	1230
,, 4th ..	0	174	350	477	697	908	1070	1181
New	0	204	374	498	685	896	1070	1200
Notes	*C*	*D*	*E*	*F*	*G*	*A*	*B*	*c*

Second Setting:—

Obs.......	0	183	271	534	686	872	983	1232
New......	0	204	259	498	685	896	1011	1200
Notes	*C*	*D*	*E* ffl	*F*	*G*	*A*	*B* fl	*c*

Third Setting:—

Obs.......	0	111	314	534	686	828	1017	1198
New......	0	99	316	498	685	787	1011	1200
Notes	*C*	*D* fl	*E* fl	*F*	*G*	*A* fl	*B* fl	*c*

Fifth Setting:—

Obs.......	0	90	366	493	707	781	1080	1087
New......	0	99	374	498	685	787	1070	1200
Notes	*C*	*D* fl	*E*	*F*	*G*	*A* fl	*B*	*c*

At the South Kensington Museum will be found a variety of Indian musical instruments. Many of these I carefully measured, but it was sometimes difficult to determine the real vibrating length of the string. The Vinas had their frets fastened with wax. The intervals from fret to fret were measured in cents from the inverse ratios of the length of the string, which is by no means accurate, especially as this calculation takes no account of the increase of tension caused by pressing the string down on to the fret or behind the fret. One example will therefore suffice.

Vina, from Madras, dragon-headed, with a lute body broken, and a gourd; 24 frets, fastened with wax. The I, II, &c., indicate the number of the fret, O being the nut. The intervals are expressed in cents from fret to fret, and from the open string to each fret. The frets marked (*) had been broken off, and their position was restored from traces left. For the names of the notes I have been guided by the nearest number of cents in the new Bengali division, given above.

	O	89	I	89	II	91	III	104	IV	102	V	121	VI	88	VII	97	VIII	98
	0		89		178		269		373		475		596		684		781	
Notes	*C*		*D* fl		*D*		*E* ffl		*E*		*F*		*F* sh		*G*		*A* fl	

	IX	117	X	85	*XI	118	*XII	81	XIII	96	XIV	90	XV	101	XVI	114
	879		996		1081		1199		1280		1376		1466		1567	
Notes	*A*		*B* fl		*B*		*c*		*d* fl		*d*		*e* ffl		*e*	

	XVII	95	XVIII	115	XIX	93	XX	106	XXI	97	XXII	111	XXIII	100	XXIV
	1681		1776		1891		1984		2090		2187		2298		2398
Notes	*f*		*f* sh		*g*		*a* fl		*a*		*b* fl		*b*		*c'*

Judging from the circumstance that the Rajah Ram Pal Singh began at the Fifth above the open string, it may have been more proper in this Vina to commence taking the scale from after the Seventh fret. This would make an Octave have the following intervals from the lowest notes:—

Cents...	0,	97,	195,	312,	397,	515,	596,	692,	782,	883,	997,	1092,	1207
Notes...	*G*	*A* fl	*A*	*B* fl	*B*	*c*	*d* fl	*d*	*e* ffl	*e*	*f*	*f* sh	*g*

This is very close indeed to our scale of 12 Semitones, and may be taken for it. The remaining 7 Quartertones have to be produced by pressing the string behind the fret.

The Vina is the oldest of these stringed instruments; the *Sitahr*, which is mostly used, is much more modern. Captain Meadows (Tagore collection), describing the Indian instruments presented to the Irish Academy by

Colonel French, enumerates Cymbals, Gongs, Bells, Horns, Trumpets, reed instruments (Oboes), Pipes, Four-stringed Lutes, Sitahr and its varieties, Viols, Dulcimers, Vina and Been, and one-stringed Tunteemee, Drums in great variety, Conch shell. Of these, the Oboes (*holar char soonai*) he describes as being the commonest, and to be heard everywhere. The sound is like a bagpipe, and it has no great compass, but by quarter and half covering the finger-holes great varieties of notes are introduced, and there is much execution. This must have resembled the Chinese So-na, hereafter described. Even with the assistance of a player, there would be great difficulties in recording such scales. Possibly, this oboe is an early instrument, and certainly all stringed instruments are later. But I regard percussion instruments as the most primitive, like the following: —*Balafong*, from Patna, in the South Kensington Museum—a modern harmonicon, strung over a box, which is beautifully carved, containing 3 octaves and 3 notes, or 25 bars. I give the pitch and scale of such bars as Mr. Hipkins and I measured on 6th April, 1883. The Roman II, III, &c., give the number of the bar, the pitch is written over, the cents. between and under as usual.

Vib.	158		176		194		214		233		259		279		321
	II	187	III	169	IV	170	V	147	VI	183	VII	129	VIII	237	IX
Cents........	0		187		356		526		672		856		985		1222

	321		355		391		434		484		531		582
	IX	180	X	167	XI	181	XII	189	XIII	160	XIV	159	XV
Cents (less 1222)	0		180		347		528		717		877		1036

In the first Octave, the bars IV and VII give almost the same as the bagpipe notes; but V and VI gives a sharp Fourth and a flat Fifth, having barely three-quarters of a Tone between them. The Octaves are all sharp, as is seen by the vibrations, and by the cents when 1222 are added. But the four first notes are much alike in both octaves.

Classing Cashmere under India, I may here introduce the *Tar*, a kind of guitar, with 13 movable frets, made of three turns of waxed string, about 3 mm. in width, with two strings in unison to play with, and several sympathetic strings. The frets, on the instrument mentioned, had evidently not been shifted for a long time, and I take them as I found them. The intervals on cents are determined from the vibrating lengths, that of the open string being 676 mm.

First Octave..	O	175	I	179	II	158	III	208	IV	176	V	166	VI	175	VII
	0		175		354		512		720		896		1062		1237
Second Octave	VII	205	VIII	173	IX	150	X	195	XI	221	XII	160	XIII		
	1237		1442		1615		1765		1960		2180		2341		

The Octaves are all sharp, but as the frets were very low, they could not have been much sharpened by pressure on the string behind the fret. It would seem that this was a Quartertone scale, of the type 0 200 350 500 700 900 1050 1200, the whole Tone in the second tetrachord being placed so as to make it identical with the first.

VIII.—Singapore.

Mr. Hipkins received direct from Singapore a *Balafong*, or wooden harmonicon, supposed to have come from Java; but as the scale is totally different from the Javese, I class it under the name of the place from which it was received. It consists of twenty-four wooden bars, forming three Octaves and three notes. We measured the central Octave, beginning at bar 8, as follows:—

Vib........	312		344		382		427		470		523		569		626
	I	169	II	181	III	193	IV	166	V	185	VI	146	VII	165	VIII
Cents	0		169		350		543		709		894		1040		1205

Tempered form in Quartertones:—

Vib........	312		340		382		429		467		525		572		624
	I	150	II	200	III	200	IV	150	V	200	VI	150	VII	150	VIII
Cents	0		150		350		550		700		900		1050		1200

Comparing this tempered form in Meshaqah's 24 division, we see how close are both the number of cents and number of vibrations, assuming the same initial pitch. Hence it seems right to consider that this was, like the bagpipe, a Tone and three-quarter Tone instrument, both having 3 Tones and 4 three-quarter Tones, but differently distributed. The resemblance between this scale and that of the preceding Tar of Cashmere is very striking, and would seem to imply that they belonged to the same system of tuning.

IX.—Burmah.

The *Patala*, a wooden harmonicon, of 25 small neat bars, in the South Kensington Museum, No. 1,620, 1872, Engel, p. 16, who describes the scale wrongly. Mr. Hipkins and I commenced with bar 7 from the lowest end, here written I, and took an octave with the following result:—

Vib.	300		332		367		408		451		504		551		616
	I	176	II	174	III	183	IV	174	V	192	VI	154	VII	193	VII
Cents	0		176		350		533		707		899		1053		1246
Tempered	0		150		350		550		700		900		1050		1200

The Octave is exceptionally sharp, otherwise this scale agrees closely with the immediately preceding Singapore Balafong, the tempered forms being identical. The III 350 cents is very characteristic. Bars 15, 16, 20 were sharp octaves of bars 8, 9, 13 (or II, III, IV), the bar 16 being very sharp indeed, otherwise the Octaves were fair.

There is also a Burmese *Balafong* in the South Kensington Museum, with a box decorated with Burmese ornaments. It consists of 22 bars, and contains 3 octaves and 1 note. We measured 12 bars from the 4th to the 15th. The following gives the scale from the 8th to the 15th, numbered I to VIII:—

Vib.	353		377		432		485		525		573		641		705
	I	114	II	236	III	200	IV	137	V	151	VI	194	VII	164	VIII
Cents	0		114		350		550		687		838		1032		1196
Tempered	0		100		350		550		703		850		1050		120

And the preceding 4 bars give—

	237		258		282		318		353
	IV′	147	V′	154	VI′	208	VII′	181	VIII′
Cents	506		653		807		1015		1196
Tempered	500		650		800		1000		1200

which shows that they form the end of an octave very similar, though not identical with the other one. The tempered form seems to show that this again is a three-quarter Tone scale, though differently arranged.

The *Keay Wine* in the South Kensington Museum consists of 15 kettles or gongs, resembling Javese Bonangs, arranged in a circle. Unfortunately, one gong was cracked, and another had a very doubtful pitch, and the whole instrument seemed out of tune. I consider it best, therefore, not to record the extremely doubtful measurements.

X.—Siam.

The *Ranat* in the South Kensington Museum is another wooden harmonicon with 19 bars, which Engel (p. 316) says form the diatonic scale of *G*, but this is far from being the case. We measured 10 bars from the 6th to the 15th. The 13th was unfortunately of a different kind of wood from the rest, and had been put in as a substitute for the Octave of bar 6.

Vib.	323		348		379		433		491		504		585		666
	VI	129	VII	148	VIII	231	IX	218	X	45	XI	258	XII	225	XIII*
Cents	0		129		277		508		726		771		1029		1254
Tempered	0		150		250		500		700		800		1000		1200

	666		748		794
Vib.	XIII*	201	XIV	103	XV
Cents	0		201		304
Tempered	0		200		300

This scale is quite enigmatical. The second Octave, of which only the beginning was measured, quite disagrees with the first. The interval, 45 cents, is also unintelligible. In tempering I have therefore supposed X to be too sharp, and XI too flat, but the tempering is hazardous. Let us hope that the Siamese musicians who are to come to the Inventions Exhibition of this year, will give a better notion of Siamese music than this *Ranat* affords. If I can obtain any information, I will communicate it to the Society of Arts.

XI.—Western Africa.

A *Balafong*, No. 1080, 108a—'68, South Kensington Museum, Engel, p. 154, who makes it the diatonic scale of *C* natural, beginning at *E*. This is far from being the case. We measured 9 bars, beginning at the 8th as follows :—

1. Vib..........	327		357		386		445		497		547		596		654		714
2. Bars	VIII	152	IX	135	X	245	XI	191	XII	166	XIII	149	XIV	161	XV	152	XVI
3. Cents	0		152		287		533		724		890		1039		1200		1352
4. Ratios ...		11 : 12		25 : 27		32 : 37		9 : 10		10 : 11		11 : 12		10 : 11		11 : 12	
5. Cents of r.		151		133		251		182		166		151		166		151	
6. Sums of r.	0		151		284		535		717		883		1034		1200		1351
7. Vib. of r...	327		357		385		446		495		544		594		653		
8. Tempered.	0		150		300		550		700		900		1050		1200		

The 1st line gives the vibrations observed; the 2nd the numbers of the bars and the cents between them; the 3rd the cents from bar VIII; the 4th the nearest ratios (the product of these ratios is 500 : 999 very nearly 1 : 2); the 5th the cents corresponding to these ratios; the 6th the sum of these cents (making the Octave exact, owing to the approximate nature of the cents in line 5); the 7th the corresponding vibrations, which may be compared with line 1; the 8th the corresponding tempered intervals of the 24 divisions, showing that this is one of the Tone and three-quarter Tone systems, including in this case a five-quarter Tone. The ratios are not given as if any thought of them were present to the tuner, but merely as the nearest rational expression of the intervals.

Another *Balafong* from West Africa, belonging to General Pitt Rivers, on loan at the South Kensington Museum, consisting of 14 bars, on examination, showed that the first and last bars were too defective to have their pitch measured. The other thirteen behaved thus—

Vib. ..	280		305		332		368	
	II	148	III	147	IV	178	V	and then beginning afresh at V
Cents...	0		148		295		473	
Temp...	0		150		300		500	

Vib. ..	368		412		435		495		547		583		659		740		830
	V	195	VI	94	VII	224	VIII	173	IX	110	X	212	XI	201	XII	199	XIII
Cents...	0		195		289		513		686		796		1008		1209		1408
Temp...	0		200		300		500		700		800		1000		1200		
Say	*c*		*d*		*e* fl		*f*		*g*		*a* fl		*b* fl		*c'*		

So that bars V to XII give a very fairly correct minor scale without the leading note. Compare with the scale of *F* sh minor in French pitch, of which the vibrations are—

Vib...	366	411	435	488	548	581	652	732
Note...	*f* sh	*g* sh	*a*	*b*	*c'* sh	*d'*	*e'*	*f'* sh

Second Division.—Pentatonic Scales.

XII.—South Pacific.

To Europeans the type of the Pentatonic Scale is furnished by the black digitals on the piano. If we begin at *C* sh and play on to its Octave, keeping to the black notes, we should get a pentatonic scale. This would, however, be different if we began on *D* sh, *F* sh, *G* sh, or *A* sh. It is advisable to play these five scales from *C* only, and they then become the following varieties of our usual scales :—

1.—	*C*	200	*D*	300	*F*	200	*G*	200	*A*	300	*c*.
2.—	*C*	300	*E* fl	200	*F*	200	*G*	300	*B* fl	200	*c*.
3.—	*C*	200	*D*	200	*E*	300	*G*	200	*A*	300	*c*.
4.—	*C*	200	*D*	300	*F*	200	*G*	300	*B* fl	200	*c*.
5.—	*C*	300	*E* fl	200	*F*	300	*A* fl	200	*B* fl	200	*c*.

Observe that the notes in these scales could all be obtained from the following series of Fifths, beginning for each scale with the note under its number, and continuing for 5 notes:—

5	2	4	1	3				
*A*fl	*E*fl	*B*fl	*F*	*C*	*G*	*D*	*A*	*E*

This also gives a method of tuning any one of them by Fifths up and Fourths *down* (tempered on the piano). All these scales sound deficient in our heptatonic ears, and in reality a scale seldom occurs in any pentatonic music. These scales seem to have originated the notion that pentatonic scales were played because the nations that used them could not appreciate Semitones. This, as we shall see, is entirely erroneous, and, consequently, the five scales just considered are by no means all. Again, it is found that intervals of three-quarters and five-quarters of a Tone, and even more, occur. Hence the real division of the Octave in a pentatonic scale is very varied. Compare also the 160 Indian forms, formed by omission, and enumerated by Rajah S. M. Tagore.

The one we commence with is not a bad specimen of the typical scale, but both the major Third, *C* to *E*, and the Fifth, *C* to *G*, are flat. It is from a balafong (labelled Jews' Harp), of 18 bars, belonging to General Pitt-Rivers, and examined, when on loan, in room L of the Science Collections of the South Kensington Museum. Only the best Octave was selected, beginning at bar VI, but all the Octaves are tolerably good:—

Vib.	332		373		411		493		559		664
	VI	202	VII	168	VIII	315	IX	218	X	290	XI
Sums ..	0		202		370		685		903		1123
Say	*C*		*D*		*E*		*G*		*A*		*c*

The *E* and *G* are, however, both nearly a comma too flat. In fact the *E* is about half-way between Zalzal's 355 cents and the just 386 cents, so that it would be difficult to say which it was meant for, had not *A* been 903 in place of Zalzal's 853 cents, which shows that probably the just major Third was meant. This is, therefore, the 3rd pentatonic scale of the above series.

XIII.—Java.

In the summer and autumn of 1882, a complete band from central Java was performing four times daily at the Aquarium. My attention was drawn to them by two articles, written, as I subsequently found, by Mr. W. Stephen Mitchell, M.A. of Gonville and Caius College, Cambridge, in the *Journal of the Society of Arts* (for Sept. 29th, 1882, vol. 30, p. 1019, and Nov. 3rd, 1882, vol. 30, p. 1072), explaining generally the nature of the scales, their names and the order of their notes. As these articles showed the genuineness of the exhibition, I felt that there was an opportunity of determining the nature of the Javese scales* which was not to be neglected. I enlisted Mr. Hipkins, to whose valuable co-operation in all these examinations the very existence of this paper is due, and Mr. Mitchell having kindly procured us admission to the instruments at the Aquarium when not open to the public, we spent many hours in determining their pitch and scales. In doing so we found the previous work of Mr. Mitchell of great service. He had determined the names of the notes, and pasted them on to the backs of the instruments; and he had determined the order of the bars in the different scales, with considerable difficulty, as the Javese players could not speak English, and the Dutch superintendent did not understand music. Drawings and descriptions of the instruments, and some airs may be found in Sir T. Stamford Raffles's "History of Java," vol. i., and in Mr. J. Crawfurd's "History of the Indian Archipelago," vol. i., the latter reprinted at the end of Rajah S. M. Tagore's collection, although the music is totally distinct from that of India. Subsequently Professor Land, of Leyden, to whose labours on Arabic music I owe so much, was kind enough to measure some Javese instruments at Leyden with a monochord, and to communicate measurements of them made by other observers, all of which greatly confirmed our results, and showed that we were dealing with genuine instruments which had not been tampered with. Professor Land also kindly communicated much information from the MSS. of a missionary in Java, and the verbal reports of a Eurasian,† from Java, then in Holland, who spoke Javese, and could himself play on Javese instruments, as well as on the European violin. This Eurasian stated that Javese instruments, especially those of wood, are apt to get out of tune. The Ethnological Museum, at Leyden, consequently ordered some

* It is usual to say *Javanese*, which I have found continually mistaken for *Japanese* in conversation. Hence as from China and Burmah, we make the adjectives *Chinese* and *Burmese*, I shall always make the adjective *Javese* from Java.

†*Eurasian* means of mixed *Eur*opean and *Asian* parentage.

of glass, which Professor Land has since informed me are actually on the way. If Mr. Hipkins and I ever have an opportunity of measuring them, I will communicate the result to the Society of Arts. In the meantime, everything concurs to give me considerable confidence in our results.

The Javese bands are called *Gamelan*, and those which were in London were composed of two distinct bands, the *Gamelan Salêndro** and the *Gamelan Pèlog*, which must be considered separately. The performers were the same for each, but the instruments and scales were so different that they could not be played together, but were ranged on different sides of the platform. With two exceptions the instruments were all of percussion, bars of wood, bars of metal, kettles, gongs. The exceptions were 1) a solitary *rabab*, the Arabic two-stringed viol, which, having no frets, could of course be played with either band, and 2) a flute or *soeling*, but I do not remember whether it was played with one band or both. Although many instruments were played together, there was no harmony in our sense of the word. Either all the instruments played in unison, or one, generally with the highest and most evanescent tone, flourished away between the notes, regardless apparently of what the other instruments were doing, but falling into unison sufficiently to show that it was playing a part in the same music. There were no written notes. Phrases were repeated till, on a given signal, they were changed.† The music was used as an accompaniment to dancing, or rather posturing, by performers of both sexes, who were supposed to convey a story in dumb show. There was occasional singing, but the singing voice was so dreadfully, and apparently intentionally, unmusical, that it could not enter into our examination. Mr. Hipkins and I overhauled the instruments of both bands, three of each, to see that they agreed, which was generally very well, or mark where they disagreed, which was seldom, and to a slight extent.

First Band or Gamelan Salêndro.—Instruments examined:—(1.) The *Gambang Kajoe*, or wooden harmonicon of 20 bars, containing 4 Octaves, of 5 notes to the octave, ranging from 135 to 1,880 vib., so that the second Octave of the lowest note (called *bem*, evidently the Arabic *al-bamm*, for the lowest note on the lute), would have had 540 vib., the concert pitch of our English c'' on the third space of the treble staff. The tone, produced by striking with a soft wooden hammer, was sweet, but very brief and difficult to measure. (2.) The *Sáron*, a set of metal bars, divided into three sets for convenience, each containing six bars, so that the highest note of one set was the Octave of the lowest, and was repeated in unison as the lowest note of the next set. These were played with harder hammers, and damped with the thumb of the left hand. The sounds involved dissonant upper partial tones, which rendered it difficult to determine the pitch. (3.) The *Slèntem*, an octave lower than the Sáron, made of larger metal bars with bosses on them. Prof. Land also observed a Sáron in the Museum at Leyden, and Dr. Figée had observed four notes of the same previously.*

The names of the five notes of the Salêndro Scale are I Bem, meaning "lowest," II Pengoeloe, "highest;" III. Peneloe, "third;" IV Lima, "five;" V Nenem, "six," varied as Barang, which was a Pèlog note only in the instruments we examined. It is uncertain whether there were two Salêndro Scales with a different V. or not. I am inclined to think not, and that this was only another name for the same note in other part of the country, for the names certainly varied.

* In these Javese names I adopt the orthography of Prof. Land as more exact than Mr. Mitchell's. The English reader must remember that a^{o} is nearly *awe*, *oe* is *oo* in *book*, *j* is the consonant *y*.

† The above gives my own recollections. I am glad to be able to add Professor Land's account. "The musical treatment is this. The rabab plays the tune in the character of leader"; [at the Aquarium, the player of the Gambang seemed to be leader] "the others play the same tune, but figured, and each for himself and in his own way; the sáron resumes the motive or tune. All this is accompanied by a sort of *basso ostinato*, and a rhythmical movement of the drum, and the whole is divided into regular sections and subsections, by the periodical strokes of the gongs and kenongs (kettles). The variations of the same tune by the different instruments produce a sort of barbarous harmony, which has, however, its lucid moments, when the beautiful tone of the instruments yields a wonderful effect. But the principal charm is in the quality of the sound, and the rhythmical accuracy of the playing. The players know by heart a couple of hundred pieces, so as to be able to take any of the instruments in turn." He was speaking of "the gamelan band sent by the independent prince of Solo," to the Arnheim Industrial Exhibition, in the summer of 1879.

* Dr. Figée labelled them *D*, *F*, *G*, *A*, and these labels remain upon them, and would give the intervals *D* 300 *F* 200 *G* 200 *A*. But he assigned the relative pitch numbers *D* 1000, *F* 1151, *G* 1346, *A* 1520 vib., which would give the relative pitches *D* 243 *F* 274 *G* 208 *A*, in which the first two intervals are manifestly incompatible with any European scale. It is such rough and ready naming of notes which is so misleading in similar descriptions. Dr. Figée, Assistant in the Physical Laboratory at Leyden, measured by means of a good monochord, and his measurements, agreeing closely with Prof. Land's, were probably correct for that particular instrument. He was also a good singer, yet he confused intervals of 243 and 274 cents, with 300 and 200 respectively, the less with the greater and conversely.

Poensen, a missionary, used I Bárang, II Goeloe, and also Penanggap or Djongga, III Tengah, IV Lima, V Nem. The very meaning of the first set of names show that they indicate a different order of the notes from that observed. Hence the Roman numerals are best used.

The following are our observations; the notes marked (*) were out of tune, as shown by the other instruments:—

SALENDRO SCALES.

1. Gambang	*268		308		357		411		470		*535
2. Sáron	272		308		357		411		471		543
3. Slentem	270		308		357		411		469		540
4. Mean	270		308		357		411		470		540
5. Notes	I	228	II	256	III	244	IV	232	V	240	I′
6. Cents	0		228		484		728		960		1200
7. Lower Gendér	I	191	II	251	III	249	IV	261	V	220	I′
8. Upper Gendér	I	219	II	256	III	261	IV	223	V	288	I′
9. Land Sáron	I	270	II	200	III	266	IV	239	V	243	I′
10. Figée Sáron	I	275	II	210	III	..	IV	..	V	243	I′
11. Tempered	I	240	II	240	III	240	IV	240	V	240	I′
12. „ sums	0		240		480		720		960		1200
13. „ vib.	270		310		356		409		470		540

Lines 1, 2, 3, give the number of vibrations observed in the different instruments named, the Gambang being evidently wrong in I and I′, but otherwise a very substantial agreement existing.

Line 4 gives the mean number of vibrations adopted.

Line 5 shows the intervals between the notes in cents.

Line 6 gives the intervals from I in cents.

Lines 7 and 8 give the result of Professor Land's observations on the lower and upper Octave of the Gendér (another metal harmonicon) by the monochord, made with great care and difficulty, with the assistance of Prof. Onnes of the Physical Laboratory, several times over, and not always with the same results.

Lines 9 and 10 gives Prof. Land's and Dr. Figée's observations on the Sáron, only the intervals being given; Dr. Figée's were incomplete.

Lines 11 and 12 give my own tempered account, of which more presently, and line 13 gives the vibrations which would be due to these intervals, and which agree very closely with the mean of those observed.

The great peculiarity of this scale is that it contains five intervals, each of which, by our observations, was considerable greater than a major Tone of 204 cents,* and less than a just minor Third of 316 cents or even a Pythagorean minor Third of 294 cents. Under such circumstances, a European ear would naturally hear them as a tempered Tone 200 cents or a minor Third 300, as came convenient. Hence we find Sir Stamford Raffles using the notes (which I regard as in mean tone temperament in 1817), *D* 193 *E* 193 *F*sh 310 *A* 193 *B* 310 *D*′, and Crawford (who may have thought of equal temperament) using *D* 200 *E* 300 *G* 200 *A* 200 *B* 300 *D* at one time, *C* 200 *D* 200 *E* 300 *G* 200 *A* 300 *C* at another, and at a third time *D* 200 *E* 200 *F*sh 300 *A* 200 *B* 300 *D*, which is only the equally tempered version of Raffles', the same in intervals as Crawford's second, but differing from his first. A German musician, whom I met at the Aquarium, selected *C* 200 *D* 300 *F* 200 *G* 200 *A* 300 *C* for the scale we measured, whereas V. is nearer *B* fl than *A*, so that *C* 200 *D* 300 *F* 200 *G* 300 *B*fl 200 *C* would have been nearer. But this involved going out of the key of *C*, and hence was not thought of; and even when I drew attention to it, it was not admitted. It is evident, however, that the Thirds may have been otherwise placed; but they were generally so chosen as to correct the errors arising from taking the preceding interval too small, and as they over corrected, the following interval had also to be too small. This would give 0 200 500 700 1000 1200 for 0 240 480 720 960 1200 and are the nearest round numbers of cents to take. By comparing lines 4 and 13, it is seen that it would require an exceeding small alteration in the numbers of vibrations to reduce the observed to the tempered intervals, as I found, practically, in altering a set of tuning-forks from the line 4 to the line 13 pitches.

It seems an extravagant supposition that a semi-civilised nation should have hit upon

* One of the intervals in the lower Octave of Gendèr is estimated by Prof. Land as 191 cents, and one as 200 cents; that these arose either from a faulty observation or from the notes being out of tune, appears probable, by their being opposed to all the others.

the idea of dividing the Octave into five equal parts of 240 cents each, which I call a *pentatone*. Of course no such idea occurred to them, but they only fell upon it, and as I conceive thus. They took the Octave correct, and then the Fourth a little too flat, say 480 cents, which is 18 cents or not quite a comma too flat. This gives I, I′ and III. A second Fourth of the same kind from III gives V. Then working downwards from the Octave, a flat Fourth down gives IV 720 cents, and another gives II 240 cents. Of course they were never likely to take the intervals quite correctly. Thus in the case we measured, III is 484 cents, and IV is 960 cents, so that the first flat Fourth was too sharp (484 cents), and the next too flat (476 cents). Then going down from the Octave, the Fourth was taken too small as only 472 cents, giving IV 728 cents, and then the next was taken as 500 cents, much too wide giving II 228 cents. This process would succeed, but give different values to the notes whatever the Fourth chosen, for example, just Fourth 498 cents gives—

I 204 II 294 III 204 IV 294 V 204 I′
0 204 498 702 996 1200

Mean tone Fourth 503 cents gives—

I 194 II 309 III 194 IV 309 V 104 I′
0 194 503 697 1006 1200

It is clear that no supposition which does not make the Fourth flat will represent the results observed, and that allowance must always be made for taking the Fourths unequally —as is the case even with the best English tuners. It appears to me that the "tempered" scale I have suggested is much simpler than de Lange supposed (quoted by Professor Land), namely, that III was 498 cents, IV 702 cents, that is, that they made a perfect Fourth and Fifth with I, and then that the Fourth on each side was divided into 7 : 8 = 231 cents, and 6 : 7 = 267 cents or conversely, and it is certainly much nearer to the observed facts, while it is more conformable to habits of tuning. I therefore assume the equal division of the Octave into five pentatones of 240 cents as the probably unrecognised ideal of the Salêndro tuner.

Is this ideal also the ideal of all pentatonic scales? Certainly not, at present, as will be seen more particularly from our Chinese and Japanese results. After once a conception of a just Fourth and Fifth have been formed, then the scale just given

I 204 II 294 III 204 IV 294 V 204 I′
0 204 498 702 996 1200

probably becomes normal, and with a little trouble the positions of the 204 and 294 may be varied, III and IV or one of them remaining constant, see scales Sect. XII.

We do not, however, find these varieties in the Salêndro in Java. But there is some suspicion of cases in which one tone is replaced by another, in the information given to Prof. Land, but I have not been able to discover what the tone is. There are many other Pentatonic scales in Java, as we shall see presently, but they are decidedly not Salêndro in character.

This simple scale is capable of much variety of melody, varied greatly by rhythm, strict time being necessarily kept when many instruments play in music. The three airs given by Raffles and the six* by Crawford are all for the Salêndro scale.

It however appeared not to be the favourite with the Javese at the Aquarium, who more frequently played in the kind of scale next described.

The Second Band or Gamelan Pèlog.—In the first band we had five notes in a scale, and the interval between the consecutive notes was always greater than a whole Tone, but less than a minor Third. In the second band we have seven notes, with intervals between consecutive notes, varying from a Semitone of 100 cents to just over a minor third of 300 cents. But of these seven notes, only five are selected to form the scale used at any time, and each different set of five notes forms a new scale, so that the intervals between consecutive notes may vary from a Semitone of 100 cents to a sharp Fourth of 550 cents. The two bands are, therefore, widely distinct. As the case in which the Gambang is fixed will only accommodate five notes to the Octave, any unused bar has to be thrown out and replaced by another, and sometimes the order of those retained has to be changed. Hence the scales are called *sòcòggan* or extra bars. The instruments examined were the *Gambang*, the *bonang*, or collection of kettles with bosses, resting in square holes left by pieces of crossed girth on a frame, and a *Sáron*. The Sáron had all 7 bars in order of sharpness, and there was no more shifting than there is on a piano when we select different sets of 7 notes to an Octave out of the twelve on the instrument. In the *bonang*, where the kettles take up much room, this would be inconvenient. All are left on the framework,

* Crawford gives seven airs, but the seventh is Malay, not Javase, and not pentatonic, but, as noted, heptatonic.

but the kettles not in use are put at a distance, and those employed brought near. Of these "shifts" or scales, four were made out by Mr. Mitchell, and two others (Miring and Menjoera) have been conjecturally added by me from Professor Land's notes, but the indications furnished to him were too indistinct and imperfect for me to feel sure that I am right in my conjecture.

The names of the notes are partly the same as those of the Salêndro and partly different, but those having the same name have not the same pitch. Indeed, no note of one band exactly coincided in pitch with any note of the other band. When it is necessary to distinguish the Salêndro and Pèlog numbers of notes, s. or p. will be added, thus, Ip, Is. The names are Ip Pengoeloe = IIs. IIp Peneloe = IIIs. IIIp Pèlog. IVp Lima° = IVs. Vp = Nenem = Vs. VIp Barang. VIIp Bem = Is.

The *Gambang*, or wooden harmonicon, had 19 bars, or three complete octaves and four notes of the fourth octave, and because Pengoeloe was its lowest note, I have made all the Pèlog scales begin with it, but I have no other reason for so doing. Two of the notes of this instrument marked * in the following table, are shown by a comparison with the other instruments to have sharpened.

The *Bonang Pelog* had two rows of kettles forming octaves with each other and beginning with Barang and not Pengoeloe. These are struck on the boss at top with two padded wooden sticks, called *tapoes*, which are also used to damp the sound.

The *Sáron Pelog* consisted of metal bars like those of the Sáron Salêndro, but of a very different shape and quality of tone. It consisted of three octaves all but one note, distributed on three sets of seven bars, the octave above lowest bar being on the next highest instrument, and the higher octave of the lowest note of the highest set being missing. Each set was played by a different performer.

Pèlog Notes and Scales.

1. Gambang ..	*283		*311		365		391		416		448		*532		566
2. Bonang	278		302		361		390		417		448		526		556
3. Sáron	279		302		360		387		414		447		524		558
4. Adopted. ..	279		302		361		389		415		448		526		558
5. Notes	I	137	II	309	III	129	IV	112	V	133	VI	278	VII	102	I′
6. Cents	0		137		446		575		687		820		1098		1200
7. Pelog	I	446	—		III	129	IV	112	V	414	—		VII	102	I′
8. Dangsoe ...	I	137	II	550	—		—		V	133	VI	278	VII	102	I′
9. Bem. E ...	I	137	II	438	—		IV	112	V	411	—		VII	102	I′
10. ,, L ...	I	147	II	416	—		IV	96	V	429	—		VII	112	I′
11. Barang E...	I	137	II	438	—		IV	112	V	133	VI	380	—		I′
12. ,, L ...	I	151	II	426	—		IV	111	V	179	VI	333	—		I′
13. Miring	I	446	—		III	129	IV	245	—		VI	278	VII	102	I′
14. Menjoera...	I	137	II	309	III	129	IV	523	—		—		VII	102	I′

Line 1.—The pitch numbers as determined from the Gambans, the notes marked (*) being evidently out of tune.

Line 2.—The pitch numbers from Bonang.

Line 3.—The pitch numbers from Sáron.

Line 4.—The pitch numbers adopted as most probable.

Line 5.—The seven Pélog notes with the intervals between them in cents.

Line 6.—The intervals in cents of each Pélog note from the lowest. It should be remembered that these seven notes do not form a scale, but that the scales which follow consist of five notes selected from them, and that these intervals hold for those notes selected over the numbers of whieh they stand.

Line 7.—The five notes in the scale Pelog with the intervals in cents between them.

Line 8.—The five notes in the scale Dangsoe, with the intervals between them. The interval II 961 VII which occurs in this, the Bem (line 9), and the Menjoera (line 13) scales, is the same as the Salêndro interval II 960 V, and approaching closely to that of the 7th harmonic 4 : 7 = 969 cents, has a very sweet effect, especially in descending from VII to II. This Dangsoe is said, by Prof. Land, not to be mentioned by the missionary Poensen, and only the Eurasian Rhemzev was able to tell him that it was probably an importation from China, and was used by the Chinese dancers in Java. It was certainly much used by the Aquarium Javese, and had a very pleasing effect.

Line 9.—The five notes of the Bem scale according to our determinations.

Line 10.—The Bem scale as determined from

another set of instruments, with the aid of a monochord, by Dr. Loman, in 1879, as kindly communicated by Prof. Land. Although there is throughout a disagreement, amounting at II to a comma, 22 cents, and elsewhere to 18, 14, 10 cents, yet the differences are not all in the same direction, and there is a substantial agreement which is confirmatory.

Line 11.—The five notes of the Barang scale, according to our determinations.

Line 12.—The Barang scale according to Dr. Loman. The disagreements here are greater, Dr. Loman is 14 cents sharper for I to II, 12 cents flatter from II to IV, and 46 cents, nearly a quarter of a Tone, sharper for V; but 47 cents, or nearly the same amount, flatter for VI. These may have been original differences, or have come on through circumstances. Still there is a substantial agreement throughout.

Line 13 contains the five Tones which I conjecture to have belonged to the scale Miring, which means "half-and-half." As thus conjectured, it begins like Pèlog, line 7, and ends like Dangsoe, line 8. The information is from the Missionary Poensen, as interpreted by Prof. Land.

Line 14 contains the five tones which I conjecture may have been meant by an impossible indication of Mr. Poensen's. But it is, first, a merely conjectural alteration of the intervals given as 1, $\frac{1}{2}$, $\frac{1}{2}$, $2\frac{1}{2}$, $\frac{1}{2}$ Tones, which contain only 5 Tones, and is therefore impossible, into 1, $1\frac{1}{2}$, $\frac{1}{2}$, $2\frac{1}{2}$, $\frac{1}{2}$ Tones, which is possible; secondly, taking the nearest Pèlog intervals; and thirdly, identifying it with the lost Menjoera, as it is the only scale containing so large an interval as $2\frac{1}{2}$ Tones, or 500 cents.

The first four scales were determined at the Aquarium by Mr. Mitchell, so far as the names or order of the notes were concerned and verified by us, and I think we have succeeded in giving substantially the intervals employed. The following are observations of Mr. J. A. Wilkens, from Solo, Java, a first-rate authority upon native speech and manners, according to Prof. Land, from whom I obtained them:—" Not all gamelans, even of the same style, agree as to the relations of the notes. A difference of a quarter of a tone makes no dissonance to the Javese ear, for instance the *manis* [which Prof. Land identifies with VII of pèlog] of one gamelan will be (say) *F*, and that of another between *F* and *F* sh, whereas in both the note before was E." This must be considered a mere illustration, but ought to refer to some Pèlog scale; a difference of a quarter of a tone in the Barang scale has been pointed out in the observations on line 12. Mr. Wilkens continues:—" People would put these differences to the account of personal taste; I think they must be a defect in the instruments themselves," and proceeds to give his reasons, which I omit. Mr. Poensen (1872) in quoting these remarks says:—" Observe that the writer is talking about instruments which he has examined at the residences of native noblemen and princes in Middle Java. Now, what must be the condition of such instruments as we find among tradesmen and peasants, which are played upon continually, often badly preserved, and incessantly transported from place to place." Unfortunately, Mr. Wilkens is no authority on music, for he gives us a scale of *six* notes, and $5\frac{1}{2}$ Tones to the Octave, both impossible in Java, and the second everywhere, and Mr. Poensen is also unsatisfactory as a musical authority. But Mr. Rhemzev, the Eurasian, who can play Javese instruments, told Prof. Land, before he had seen these passages, that "tuning of a gamelan, even of the copper and gongsa (copper and tin alloy) instruments, suffers terribly from transporting and even from a few weeks of disusage." The former ill-effects may have happened to the Aquarium instruments (if the musicians could not retune them), and the latter to those preserved unused for years in the Dutch Museums. At any rate this fact may partly account for the discrepancies observed. The difference of observing by forks and monochord in a case of such difficulty would account for the rest, even if, as we have no right to assume, Javese tuners were much more accurate than English tuners.

I think, then, that we are justified in assuming some tempered form, as we did for Salêndro, round which to group the various determinations of the intervals. This I have found very difficult to do satisfactorily, but the following approximates very closely to observations. I take three kinds of interval, the Semitone 100 cents, the well-known three-quarter Tone, 150 cents, and the minor Third 300 cents which is double the last interval, and

instead of observed........	I	137	II	309	III	129	IV	112	V	133	VI	278	VII	102	I'.
Sums	0		137		446		575		687		820		1098		
I propose tempered	I	150	II	300	III	100	IV	150	V	100	VI	300	VII	100	V.
Sums	0		150		450		550		700		800		1100		1200
Tempered less observed ..			13		4		—25		13		—20		2.		

that is, only in one case does the difference exceed a comma of 22 cents, and only in one other case does it come near to a comma.

We then get the following results for comparison :—

Effects of Tempering.

1. Obs. vib.	279		302		361		389		415		448		526		558
2. Tempered vib.	279		304		362		383		418		443		527		558
3. Tempered notes	I	150	II	300	III	100	IV	150	V	100	VI	300	VII	100	I′
4. Tempered sums	0		150		550		700		700		800		1100		1200
5. Obs. sums	0		137		446		575		687		820		1098		1200
6. Tempered less obs.	0		†13		† 4		—25		*13		—20		* 2		0
Tempered scales :—															
7. Pèlog	I	450	—		III	100	IV	150	V	400	—		VII	100	I′
8. Dangsoe	I	150	II	550	—		—		V	100	VI	300	VII	100	I′
9. Bem	I	150	II	400	—		IV	150	V	400	—		VII	100	I′
10. Barang	I	150	II	400	—		IV	150	V	100	VI	400	—		I′
11. Miring	I	450	—		III	100	IV	250	—		VI	300	VII	100	I′
12. Menjoera	I	150	II	300	III	100	IV	550	—		—		VII	100	I′

With the exception of those involving quarter tones, which are not many, these intervals would certainly please a European ear better. We have the Fifth in the first four scales nearly pure, in place of flat. We have a Fourth very good between V and I′ in the same. We have a major Third between V and VII in the first three scales, and also between II and IV in the third and fourth scales, and between VI and I′ in two, perhaps three scales, and a minor Sixth between I and VI. We have the minor Third in Dangsoe between VI and VII, and possibly in Miring. We have the three-quarter Tone between I and II in three, perhaps four, scales, and between IV and V in three scales. But we have not a tone anywhere. The Semitone is found between III and IV in one scale, between V and VI in two scales, and also between VII and I in three, perhaps five scales. There is also an approximate subminor or harmonic Seventh (950 for 969 cents) between II and VII in two, perhaps four scales.

We should not go wrong more than a quarter of a Tone, and that only in the first two notes, if we assumed I 100 II 300 III 200 IV 100 V 100 VI 300 VII 100 I′, which would give us the tempered *C C*sh *E F*sh *G G*sh *B C* for the 7 Pèlog notes, and this would give the scales, Pelog *C E F*sh *G B C*, Dangsoe *C C*sh *G G*sh *B C′*, Bem *C C*sh *F*sh *G B C′*, and Barang *C C*sh *F*sh *G G*sh *C′*. And although these are bad imitations, especially as regards the *C C* sh *E*, when they come together, yet they are the best imitations of the Pèlog scales, which our radically different scale can produce. No one seems to have ventured on giving Pèlog airs in European notation.

The Pèlog scales of Java quite dispose of the notion that Pentatonic scales are confined to intervals of a Tone and a minor Third, for we do not find a Tone in them anywhere, and the minor Third is rare, while the Semitone is frequent.

XIV.—China.

There is a long description of Chinese music in Amiot, and shorter ones in Barrow Williams, and Dennys, and another in the catalogue of the Chinese court at the Health Exhibition of 1884, the last having numerous airs in European notation.* All of these books seem to assume as undoubted that the Chinese musical intervals are the same as the European. Amiot begins by giving the relative lengths

* *Père Amiot's* account occupies the whole of vol. vi. of "Mémoires concernant l'histoire, les sciences, les arts, les mœurs, les usages, etc., des Chinois, par les Missionnaires de Pe-kin," Paris, 1780.

John Barrow, (late private secretary to Lord Macartney and his suite as Ambassador from the King of Great Britain to the Emperor of China). "Travels in China," 4to, 1804, pp. 314.

S. Wells Williams, LL.D. of Yale, "The Middle Kingdom," 2 vols; the edition I saw was 1883.

N. B. Dennys, M.R.A.S., "Short Notes on Chinese Instruments of Music, read before the North-China Branch of the Asiatic Society on October 21st, 1873," with numerous illustrations, and the Chinese characters for each instrument named.

China Imperial Maritime Customs. Illustrated Catalogue of the Chinese Collection of Exhibits for the International Health Exhibition, London, 1884. Published by order of the Inspector-General of Customs, pp. 143—180. The short essay there given is merely an abridgment of an elaborate quarto treatise of 84 pages, with plates and music, and all the Chinese characters, by J. A. van Aalst, forming No. 6 of the "Special Series," published by the Chinese Imperial Maritime Customs, entitled "Chinese Music," to be had of P. S. King and Son, Canada-buildings, King-street, Westminster, easily procurable, and very complete.

of the string and names for the principal five tones, to which I give the corresponding English names, and the implied intervals in cents.

Relative Lengths of string	81		72		64		54		48		
Names.—	Koung		chang		kio		tsché		yu		
Solfeggio ...	fa		sol		la		ut		re		
Notes	*F*	204	*G*	204	*A*	294	*C*	204	*D*	294	*F*
Cents	0		204		408		702		906		1200

Then on p. 28 he develops this into a series of twelve notes forming perfect Fifths or Fourths, that is completely Pythagorean, as *F C G D A E B F*sh *C*sh *G*sh *D*sh *A* sh which give the 12 *lu*. These, with the Octave of the first *C* he found in the *cheng* of 13 tubes. If so, his cheng (the *shêng* of the catalogue and pronounced *shung* rhyming to *sung*) was entirely different from the one we examined. In the second part, fig. 18, he gives the calculation in the 12 *lu*, by a modern Chinese, as ratios to 10 figures, and these give the equally tempered scale exactly.

The catalogue says that at B.C. 1300 the scale had only five notes *C D E G A*, the scale on the black notes of the piano beginning with *F*sh (No. 3 of sect. XII). About B.C. 1100 two more notes were introduced, so that the scale corresponded to *C D E F*sh *G A B c*, which is a tempered form of the *F*-mode of Sect. V., and differs from our scale in having a Tritone *C* to *F* sh, instead of a Fourth *C* to *F*. This remained the scale till the invading Mongols introduced *C D E F G A B c*, and it is curious to note that, if the first scale is begun on *G*, thus, *G A B C D E F*sh *G*, the intervals are precisely the same as the second scale. Kublai Khan (A.D. 1259) endeavoured to reconcile the two by making the scale *C D E F F*sh *G A B C c*, which in modern language allowed of the modulation from the scale of *C* to its dominant *G*. But in the thirteenth century the Ming dynasty excluded all notes producing Semitones, and employed only the notes *C D F G A C*, which gives the scale of the black notes on a piano beginning with *C*sh. But the present Tsing dynasty, which has existed from A.D. 1644, reverted to the former scale excluding *F*sh, and hence retaining only *C D E F G A B C*, which is said to be "the Chinese gamut of the present day." But it is added that though "present Chinese theoretically admit seven sounds in the scale," they "practically only use five." It is pointed out however that whereas the ancient five were *C D E G A C*, the modern are *C D F G A C*, which puts the first minor Third nearer the commencement. Now, turning to the specimens in the catalogue, I find No. 1, which is *harmonised* in the key of *B* fl (for the use of the pianofortists, I suppose, as it is quite contrary to all Chinese habits), has, taking the melody only, all the notes *B* fl *C D E* fl *E F G A*, and once uses *C* sh in the harmonies (in a chord of the diminished Seventh). We may, therefore, pass it by as not Chinese music at all, though it is called the National Anthem. Of the following Nos. 2, 3, 4, 5, 7, 10, 11 use the scale *C D E G A*, which was said to be superseded by *C D F G A*, a form found only in No. 12. A different pentatonic scale *D E G A B* occurs in No. 14, but the intervals are the same as in No. 12. In Nos. 9, 15, 16, we find a hexatonic scale *C D E G A B*, and in No. 8 only we find the full heptatonic *C D E F G A B*.

Referring to van Aalst's treatise, for further particulars of this, I proceed to our own investigations respecting the actual notes actually played by native musicians. These may have been quite false, but they were at any rate satisfactory to the ears of natives. There were six musicians attached to the Chinese Court at the International Health Exhibition, and they gave vocal and instrumental performances several times daily in the tea-room and restaurant attached. By the politeness of Mr. J. Duncan Campbell, one of the Commissioners of Chinese Customs, representing China at the Exhibition, and of Mr. Neumann, the secretary, Mr. Hipkins and I were enabled to "interview" the musicians on four mornings in July and August, 1884, for two hours at a time, with the help of an interpreter, in the large dining-room of the Chinese contingent of thirty-one natives, close to the houses erected for their use, near the Queen's-gate exit. We were thus enabled to get the musicians to play us the scales of their instruments and take the pitch of the individual notes by means of my forks. We met the utmost readiness to oblige from the Chinese musicians, who were extremely good-natured. But there was great difficulty in taking the pitches, and two instruments had to be revised. There was present on two occasions an English violinist, who was engaged to teach the musicians English tunes, and he said that he had the utmost difficulty with passages involving semitones. We heard also one of the Chinese on his fiddle attempting to play a Scotch air, and the difficulty he had

in hitting the intervals—although, of course, on the violin, however rude, there is no material impediment to taking any intervals—was a sufficiently convincing proof that the modern Chinese intervals are not the same as ours. Similarly for their version of "God save the Queen."

The following is the result of our investigations, which would have been prolonged had Mr. Hipkins's business engagements allowed him to come oftener. As it is they present, I believe, the first attempts to record, with some degree of accuracy, the scales actually used. I say with some degree of accuracy only, for it is very possible—and, indeed, probable—that many modifications of the notes, due to difference of blowing and half stopping holes of pipes, are made in playing, which would not occur in merely sounding the scale. Indeed we had reason to suspect our flute player of involuntarily following our fork, so that we had to contrive that he should not hear it, by holding it close to Mr. Hipkins's ear instead of pressing the handle on the table.

Besides these instruments, we examined a duplicate in the South Kensington Museum, and I measured the vibrating lengths of strings on several fretted instruments. We also took the pitch of a small set of bells lent by Mr. Hermann Smith.

1. *Transverse Flute*, or *Ti-tsu* (Mr. Dennys's No. 52, van Aalst's No. 33, p. 71), a modern instrument having 7 holes besides the embouchure, open at both ends, so that the mouth hole was twice as far from the end as in ordinary English flutes; no keys.

1. Vib.	240		266		292		311		352		401		454		479
2. Notes	I	178	II	161	III	109	IV	214	V	226	VI	215	VII	93	I'
3. Sums	0		178		339		448		662		888		1103		1196
4. Pentatonic	I	178	II	270	—		IV	214	V	226	VI	308	—		I'

Line 1.—Observed vibrations.

Line 2.—Notes with the intermediate intervals in cents.

Line 3.—Intervals from lowest note in cents.

Line 4.—The intervals selected for the pentatonic scale.

This approaches an ordinary major scale, and may possibly have been intended for it, but the first two Tones are much too small, and the last three Tones much too large, so that the only notes decently in tune are VI and VI. It was an orchestral instrument, by which the stringed instruments were tuned.

2. The *Oboe* or *So-na* (Dennys, No. 56, "copper clarinet," but his figure corresponding to it is Fig. 38 of the *hsiang ti* called a "flageolet," it is No. 35, p. 72, of van Aalst, and it seems to be the Indian *Soonai*.) I use the term *oboe*, because it is played with a double reed, which is very short, so that there is a disk below the reed to protect the lips; then come two small pierced copper spheres, then a pipe with 7 finger holes in front and 2 thumb holes behind. A loose brass cone of considerable size covered the lower end, and was attached to the upper by a string. Dennys says it is a modern instrument, which agrees with its coming from India. It requires much force of breath, and the sound is very like a bagpipe, of which it seems to contain the intervals differently distributed. But it is an orchestral instrument, and is played with the flute, so that the intervals must be much "humoured" by the performer. The measurements of the pitch numbers of the notes in both this and the flute were revised.

1. Vib.	400		435		475		516		578		640		719		808
2. Notes............	I	145	II	152	III	143	IV	197	V	176	VI	201	VII	202	I'
3. Sums............	0		145		297		440		637		813		1014		1216
4. Tempered notes ..	I	150	II	150	III	150	IV	200	V	150	VI	200	VII	200	I'
5. Sums............	0		150		300		450		650		800		1000		1200
6. Vib.	400		436		476		519		582		635		713		800

The tempered form which, as is seen, agrees very closely with the observed, gives the character at once, as an instrument with the same intervals as the bagpipe (whence another cause for its close resemblance to that instrument) but differently distributed. There is no approach to a major scale here. But van Aalst gives the scale as f' (on the last space of the treble) g' a' b' fl c'' d'' e'' f'' g'', 9 notes as in the bagpipe.

3). *Reed Mouth Organ*, the *Shêng* (rhymes *sung*, and often so called, van Aalst, No. 46, p. 79), a gourd with its top cut off, and then a flat cover cemented on, into which a series of bamboo pipes are inserted, each provided with a "free reed" of copper, something similar to the harmonium reed (which is said to have been borrowed from it), but really different, because it will sound either by blowing or suction. The lengths of the tubes are ornamental, the actual length being determined by a "slot" or long hole turned from view, as on the "show pipes" of an organ. Each sounding pipe (there are two dummies for convenience of construction) has a ventage near the bottom, which must be stopped with the finger for the note to sound. The semigourd is provided with a mouthpiece or short spout, through which the performer can blow, or out of which he can suck wind (the latter is the proper method), which passes through all the pipes, so that there is a great loss of power, as only the one pipe stopped will sound.

First Octave—

1. Vib ...	450		508		547		600		680		760		820		899
2. Notes	I	210	II	128	III	160	IV	217	V	193	VI	132	VII	159	I′
3. Sums.	0		210		338		498		715		908		1040		1199

Second Octave—

1′. Vib ...	899		1017		1110		1232
2′. Notes.	I′	214	II′	151	III′	182	IV′
3′. Sums..	0		214		365		547

Tempered—

4. Notes	I	200	II	150	III	150	IV	200	V	200	VI	150	VII	150	I′
5. Sums.	0		200		350		500		700		850		1000		1200
6. Vib ...	450		505		551		601		674		757		825		900

There were only 11 notes in the particular instrument examined, which was blown (or rather sucked) for us by one of the Chinese musicians. This seems, therefore, to have the bagpipe intervals, very slightly altered in distribution. According to Mr. Hermann Smith's measurements, a Shêng in his possession should produce a series of Fifths (reduced to one Octave), which would agree with Amiot. The Shêng, I understand, very readily gets out of tune. We selected it because it is well known, and its tones are fixed.

4). *First Chime of Gongs* or Pien-lo, Wan-lo (in Dennys, No. 38, van Aalst, No. 14, p. 57,) or *Yan-lo* as called at the Chinese Court and in South Kensington Museum, from both of which we had specimens, which differed greatly. That from the Chinese Court is given here, the other in 5). A series of 10 small cheese-plate-shaped gongs in a frame, one at the top, and then three rows of three in each, here numbered as seen from behind, where they projected, and were struck by the wooden hammer, I at the top, II III IV in first row, V VI VII in second row, VIII IX X in bottom row. In the table, however, I arrange them in order of pitch. They were struck in this order, omitting IX and I. I am quite unable to give any theory for this scale, and especially for the notes IX and I omitted by the player. But I give a tempered form, which seems to suit when these are left out. We are told by van Aalst that "it has become exceedingly difficult to find a *yün-lo* capable of giving a satisfactory gamut; besides the pitch is not uniform, so that two *yün-los* rarely agree. The scale is ordinarily *C D E F G A B c d e*." It will be seen that this is nothing like the scales of those we examined.

1. Vib.	449		495		555		568		630		663		703		712		830		902
2. Notes....	VIII	169	V	198	II	40	IX	179	IV	88	VI	101	X	22	I	265	VII	144	III
3. Sums	0		169		367		407		586		674		775		797		1062		1208
4. Placed ..	VIII	169	V	198	II	219	—		IV	88	VI	101	X	287	—		VII	144	III
5. Temp. ..	0		150		350		—		600		700		800		—		1050		120

5). *Second Chime of Gongs* or Yan-lo or Yünlo from the South Kensington Museum, see 4). Engel p. 193 makes the value of the gongs in order of number to be *c*, *d a f*, *b b*fl *g*, *f* sh *e* fl *e*, out of which he says 4 peutatonic scales can be formed, *f g a c d*, *c d e g a*, *d e f* sh *a b*, *b* fl *c d f g*. I can only suppose that he was describing some other set. Neither the copy in the Chinese Court or the South Kensington Museum bears the remotest resemblance to this ingenious arrangement. Gong V was unsound, and gongs V and IX were almost identical in pitch to the ear, while gong VIII was very little sharper than gong VI. The compass of the whole scale is less than a Pythagorean minor Sixth of 792 cents. The notes in the table are in order of pitch.

1. Vib......	794		818		912		926		1011		1022		1114		1116		1198		1216
2. Notes....	I	52	II	188	III	26	IV	152	VI	19	VIII	149	V	3	IX	123	X	26	VII
3. Sums.....	0		52		240		266		418		437		586		589		712		738

Possible Scales :—

4. Fifth sharp	I	240	—		III	178			VI		171		—		IX	123	X		
5. Fifth flat..			II	188	III	178			VI		168		V		152				VII
6. Sums.....			0		188				366				534						686
7. Another Fifth flat..			II	214	—		IV		171		VIII	152			IX	149			VII
8. Sums............			0				214				385				537				686
9. Fourth...........					III	197	—				VIII	152	—		IX	149			VII
10. Sums............					0						197				349				498

Line 1 gives the vibrations observed. Line 2 the notes of the gongs in order of pitch with their intermediate intervals in cents. Line 3 their intervals from the lowest in cents. Then I show that three scales of a certain sort may be formed from the notes, but whether they were intended or not it is impossible to say. Line 4 goes to a slightly sharp Fifth 712. Line 5 goes to a slightly grave Fifth 686, only 16 cents flatter than the true Fifth which does not occur on the chime. Line 7 gives another scale up to the same. Line 9 gives a tetrachord, going to a perfect Fourth, and divided practically into a Tone and two three-quarter Tones, 200, 150, 150 cents as on the bagpipe. Two others of these three-quarter Tones are IV 152 VI and V 152 VII.

There are several other remarkable intervals. VI 19 VIII may have been meant for a comma 22, and III 26 IV and I 52 II are nearly one-eighth and one-quarter of a major Tone 204 cents.

II 188 III and III 178 VI may both be meant for the minor Tone 182 cents.

I 240 III is the exact pentatone of the Javese Salêndro scale.

II 385 VIII is an excellent major Third 386 cents. I 586 V, or I 589 IX may represent the 588 or zaïd on the second string of the Arabic lute, I 738 VII is the 49th harmonic reduced to the same octave, which cannot be more than a curious coincidence. The great difference between the two Yan-los suggest the possible existence of many other varieties.

6. *Dulcimer*, or *Yang-chin* (the "copper wire harmonicon" of Dennys No. 65, van Aalst's No. 28, p. 67), is exactly like the ordinary dulcimer (see "Grove's Dictionary of Music," p. 49), with 4 wires to each note forming two octaves, the longer set of wires passing under the bridge which limits the shorter set. It is struck by two elastic hammers. The instrument being out of tune was tuned for us by the player of the *tamboura*, 7) below, according to the Chinese names of the scale in Dr. Williams's "Middle Kingdom," namely I ho, II sz', III í, IV chang, V ché, VI kung, 7 fan, 8 liu, which are there interpreted as the major scale of *E* fl. If the conjectural restoration I have made be correct, it is rather a major scale beginning on its Second note, which may be considered as the justly intoned scale of *B* fl commencing on *C*, thus *C D E* fl *F G A B* fl *C*, but that this is "the" Chinese scale I doubt. The instrument was evidently not quite in tune, but it had the peculiar character of the *D*-mode described in Sect. V. The oboe player played us a tune upon it after the tamboura player had tuned it. The tuner had great difficulty with the semitones II 105 III, and VI 118 VII, that is with notes III and VII. He accomplished the second more easily than the first. In pentatonic playing both these notes are omitted.

1. Vib............	205		226		240		272		300		340		364		409
2. Notes	I	169	II	105	III	217	IV	170	V	217	VI	118	VII	202	I'
3. Sums	0		169		274		491		661		878		996		1198

Conjectured Just—

4. Notes	I	182	II	112	III	204	IV	182	V	204	VI	112	VII	204	I'
5. Sums	0		182		294		498		680		884		996		1200
6. Vib............	205		228		243		273		304		342		364		410
7. Pentatonic Notes	I	182	II	316	—		IV	182	V	204	VI	316	—		I'

Such a scale would of course be harmonisable, but of that I suppose no Chinese would think.

7). The *Tamboura* or *Sien tsu* (Dennys' *San-hsien*, van Aalst's No. 24, p. 66), or three-stringed guitar, No. 75, Fig. 53. The one played to us had no frets. The strings were tuned to 239, 266, and 400 vib., making the interval of 185 or say 182 cents, a minor tone, between the two first, and 706, or say 702 cents, a just Fifth between the Second and Third, much better tuning than might be expected. The string lowest in pitch was, as as usual, highest in position when playing. The strings were plucked by two plectrums of bone, looking like claws tied to the first joints of the thumb and forefinger, and projecting beyond their ends. The tone was good, and very like a banjo, which it resembled in shape. The following pentatonic scale was the only one played to us:—

1. Vib	320		357		400		480		536		642
2. Notes	I	189	II	197	III	316	IV	191	V	312	I'
3. Sums	0		189		386		702		893		1200
Just—											
4. Notes	I	182	II	204	III	316	IV	182	V	316	I'
5. Sums	0		182		386		702		884		1200
6. Vib	320		356		400		480		535		640
Transformed—											
7. Sums	498		680		884		1200 = 0		182		498

Lines 1 to 3 as usual. Then in lines 4 and and 5 I conjecture a just scale which is, in fact, *C* 182 *D* 204 *E* 316 *G* 182 *A* 316 *C'*; where line 5 agrees very closely with line 3, and on calculating the vib. on line 6, they agree almost exactly with those in line 1. Now I transform the scale by beginning it with IV = *G*, and get *G* 182 *A* 316 *C* 182 *D* 204 *E* 316 *G*, where the intervals are identical with those of the Dulcimer in its pentatonic just form, or *C* 182 *D* 316 *F* 182 *G* 204 *A* 316 *C*. Hence these two instruments practically furnish different modes of the same scale, that is, the same succession of notes begun in different places. But then it was the same man who played and tuned both.

8). *Balloon Guitar* or *P'i-p'a* (Dennys' No. 76, Fig. 52; van Aalst's No. 22, p. 64).—This was tuned by the same musician who furnished the two last scales. It has 4 strings, the lowest having 234 vib., and then its Fourth, its Fifth, and its Octave, but we did not test the accuracy of these intervals. Near the nut were 4 large, round backed, semielliptical frets, which the player did not use, and then there were 12 frets on the body of the instrument. On these frets a pentatonic scale was played, but not all on one string. The frets were indeed fixed, but the player might have easily sharpened some of the notes in the Indian fashion, for the frets were pieces of wood, rather roughly glued on, and fully a quarter of an inch high. But the top was broad enough for him to press thereon; we were, however, so fully occupied in taking the pitch, that we did not notice.

1. Vib.	320		348		392		465		530		638
2. Notes	I	145	II	206	III	296	IV	227	V	321	VI
3. Sums	0		145		351		647		874		1195
Tempered—											
4. Notes	I	150	II	200	III	300	IV	250	V	300	VI
5. Sums	0		150		350		650		900		1200
6. Vib.	320		349		392		466		538		640

This scale is like nothing I have yet met with. The quarter Tone tempering agrees very well, except in V, which is 26 cents and 8 vib. in 530 too sharp.

This completes the observations made with the help of the Chinese musicians at the Health Exhibition. But, in addition to these, I measured the lengths of strings in several instruments at the South Kensington Museum. The very great uncertainty of the scales deduced from such measurements induces me to pass over the results. I may mention, however, that these measurements show, in a second P'i-p'a, that the four large round frets already named probably gave a Fourth, divided into a Tone and three Semitones of some sort; that one "Moon Guitar" seemed intended to give 12 equal Semitones, the only trace of Amiot's scale which I have found, and another Moon Guitar seemed to divide the Octave into 8 Threequartertones of 150 cents each.

9). *The Scholar's lute*, or *Chin* (van Aalst, No 10, p. 59, Dennys, No. 70). Dennys quotes the method of tuning from Dr. Williams ("Middle Kingdom," vol. 2, p. 168), which amounts to this:—

1. Notes	I	204	II	294	III	204	IV	204	V	294	VI	204 VII
2. First Oct...	0		204		498		702		906		1200	
3. SecondOct.			0		294		498		702		996	1200
4. Say	*D*		*E*		*G*		*A*		*B*		*D'*	*E'*

This would give two pentatonic scales of whole Tones and minor Thirds differing in the position of the minor Thirds. The tuning begins at the central string *A*, and the extremes are *D*, a Fifth below, and *E'*, a Fifth above. Again, a Fourth below *A* gives *E*, and a Fourth above, *D'*. Finally, a Fourth above *D* gives *G*, and a Fourth below *E'* gives *B*. As this instrument was not played at the Health Exhibition, I had no opportunity of

measuring the pitch of its notes, and give the above indications with considerable hesitation. But it did not seem right to omit all mention of it, as Dennys says that it "stands at the head of the Chinese orchestra, occupying, to native eyes, the position taken by the violin in our own."

10). *A chime of bells,* such as I do not find named in Dennys, or in van Aalst, consisting of four small bells on a stem, so as to be struck by a hammer, were lent me by Mr. Hermann Smith. The diameters of the bells are only 43, 39, 37, 36 mm, and their heights about 10 or 12 mm, forming little shells. The sound was very shrill. Mr. Hipkins and I measured their pitch, as well as we could, as follows.—

1. Vib.	761		912		1004		1156
2. Bells	I	313	II	167	III	244	IV
3. Sums ..	0		312		480		724

These intervals are rather remarkable. I 313 II is a very good minor Third. I 480 III is exactly the theoretical flat Fourth of the Javese Salêndro, and I 724 IV is almost precisely the theoretical sharp Fifth of the same, 720 cents would be exact. Hence III 244 IV is a pentatone. As the interval II 167 III is then rather inexplicable, I feel inclined to suppose that II had been tuned much too sharp, and that we ought to have I 240 II 240 III 240 IV, part of a Salêndro scale. This would make II 874 vib. in place of 912, a difference of 73 cents, which is very great.

No theory of Chinese music can be deduced from such indications, but they serve to show that the representations by European notation usually given are utterly misleading, and require reconstruction from a detailed examination and record of what is actually heard from Chinese musicians.

XV.—Japan.

The Rev. Dr. Veeder, when Professor of Physics in Japan, gave an account of tuning the Japanese Koto, in the "Transactions of the Asiatic Society of Japan," first in 1877, and then in 1879; together with the pitches of a set of old Japanese pitchpipes, taken by the help of a siren. He also gave the pitches of notes obtained from ancient Japanese flutes, but remarked that these were certainly not those obtained by natives, who by the way of blowing and half covering finger holes could make them speak very differently. Mr. Hermann Smith lent me a set of Japanese pitchpipes (less three), but they differ materially in pitch from Dr. Veeder's indications. Both sets were in all probability much out of order. Dr. Veeder also says that the modern pipes differ from the ancient. Hence I do not give either his or our determinations.

In the Japanese Section of the Educational Division of the International Health Exhibition of 1884, there was a considerable display of Japanese musical instruments, but unfortunately no one who could play them, or who knew anything of music. Among others was a Biwa, or four-stringed lute, a handsome well-made instrument, to all appearance like Al Farabi's Arabic lute, the strings being almost in contact at the nut, but spreading out at the bridge so as to allow of being played with a wooden plectrum. This we tried first by measuring the vibrating lengths from the nuts and five frets, and then, after screwing up the open strings to convenient pitches, by taking the pitch number for each string and each fret. I give the results of the intervals from fret to fret only, as the variations are rather remarkable.

Biwa.—

Vibrating lengths	843		750		709		673		637 mm.
Cents from lengths	I	202	II	79	III	90	IV	95	V
Cents from pitch of									
Lowest string ... diam. 1·65 mm.	I	225	II	107	III	84	IV	96	V
Second lowest .. diam. 1·37 mm	I	223	II	115	III	91	IV	71	V
Second highest... diam. 1·06 mm.	I	195	II	125	III	87	IV	89	V
Highest string ... diam. 0·88 mm.	I	212	II	109	III	93	IV	89	V
Mean from pitch...	I	214	II	114	III	89	IV	86	V
Sums of mean	6		214		328		412		498
Assume	I	204	II	114	III	90	IV	90	V
Sums	0		204		318		408		498
Pythagorean notes	*C*		*D*		*D* sh		*E*		*F*

The *D* sh of 318 cents would be indistinguishable from *E* fl of 316 cents, a perfect minor Third. This tetrachord was repeated on each string, the scale played would, therefore, depend upon the methods of tuning of the string of which six were assigned, and are given later on.

There was also a *Sho,* the same sort of instrument as the Chinese Shêng, and we tried to blow it. But our results disagreed so thoroughly with what was assigned, that it must have been out of tune, or else we blew it wrongly. Hence I do not cite it.

My principal assistance came from a MS. at

the Japanese Educational Section, entitled "Extracts from the Report of *S. Isawa*, Director of the Institute of Music, on the result of the investigations concerning Music, undertaken by order of the Department of Education, Tokio, Japan, translated by the Institute of Music." The original Japanese was printed, but the extracts in English were only in MS., and Mr. Tegima, the commissioner, politely allowed me to have a copy of the parts I asked for, and said I might make use of them as I liked. The Institute of Music at Tokio was founded in October, 1878. For some time it had the assistance of Mr. Luther Whiting Mason, from Boston, as teacher of music, and after he left it, has had Mr. Eckest, a German bandmaster. The first object was to determine the difference, if any, between the Japanese and European notes. The method of procedure was as follows (abridged from the report):—

"Mr. L. W. Mason, after attentively hearing Japanese popular and classical pieces of music for the purpose, said there was no difference as to tonality [meaning evidently *intonation*], but only a little difference in the mode of the tonal combinations. Several inquiries have been put also to the best Japanese musicians, whether they thought the European intonation dissimilar to their accustomed tones. They all say there is no difference to be detected by their ears. The most striking instance to be mentioned here is that when Yamase Shoin, the best Koto musician, who had never heard European tones before, touched the pianoforte keys, he detected at once the deviations of some tones, of which he expressed his opinion that such tones could not be true according to his ear, and these tones criticised by him were indeed found by Mr. L. W. Mason to be out of tune. Students who entered the Institute, and had been most skilled in popular and classical music, made such remarkable progress [in European, having nothing to unlearn] as quite surprised Mr. Mason."

In addition to the information contained in Mr. Isawa's report, he politely wrote me a long letter in answer to my inquiries, and Mr. ——, another Japanese gentleman, who is studying physics in Europe, and is acquainted with the European violin, to whom I was introduced by Mr. Tegima, has most kindly answered a long string of questions that I sent him on the subject, but, considering himself only an amateur, he desires to remain anonymous. He represents, therefore, the views of the intelligent non-professional native gentleman.

As ro the 12 notes acknowledged by the Japanese pitch pipes, Mr. Isawa writes, that they are obtained from the lowest note by taking Fifths up and Fourths down, as in tuning the piano, but that if the Fifths and Fourths were taken perfect, the 13th note instead of being an Octave of the First, would, as is well known, be sharper by a Pythagorean comma of 24 cents, and that this "difference is equally distributed to all tones, or rather more to the tones which are not frequently used." The first would give the equal temperament, the second an accommodation temperament, such as some pianoforte tuners are said to affect. Professor Ayrton, when my paper on non-harmonic scales was read to the Royal Society (20 Nov, 1884, Proc. R.S vol. 38, p. 368), remarked, that his experience in Japan led him to conceive that the Japanese intervals were often very different from the European. Mr. —— says guardedly, that "the intervals are the same musically, but not mathematically. . . . As we have no harmony, no one can discover, by hearing, any slight deviation from the mathematical." This is an important observation, and may account for numerous discrepancies. It is evident that Japanese ears have not been cultivated for an accurate appreciation of melodic differences, and they have, properly speaking, no means of controlling their results by the beats of imperfect consonances. Mr. —— says further, that the twelve pitch pipes "give nearly the same notes as the European chromatic tones." "I had occasion," he adds, "to compare one of these series of pipes in possession of a celebrated court musician, with a series of tuning forks used by European musicians, and I found that the corresponding ones did not give beats of more than 3 in one second." Mr. Isawa, however, judged it expedient not to send me a new set of pitch pipes, because he thought they would be misleading. In fact, as I suppose, the set of pipes is not very evenly tempered, and secondly, Japanese intervals generally differ from each other considerably according to the player.

The first conclusion is confirmed by the intervals on the Biwa, which, notwithstanding their material differences, are assumed to be on each string a Tone and three Semitones, and any two of the latter taken together are considered to make the same interval as the Tone itself. The second conclusion is con

firmed by two observations on native Japanese players coming from country districts, and hence certainly unprejudiced by scientific research, who performed at the Japanese Village, at Knightsbridge, where Mr. Buhicrosan, the proprietor, kindly allowed Mr. Hipkins and myself to take down their scales. The first was a female player (and Mr. ——— says that music is generally left to the women in Japan), the second was her music master, and both were supposed to be tuning the *Koto* in the method called *hiradio-shi* (Isawa) or *hira-joshi* (———).

The Koto is the national instrument. Over a sounding board, about 6 feet long, are stretched 13 strings all of the same length (about 61 inches = 1549·4 mm.) and thickness (diam. 1·16 mm.), and, intentionally, with the same tension. Their vibrating lengths are limited by high movable bridges, which, on being inserted, necessarily increase the tension to some extent. These bridges serve to tune the strings, and they leave a considerable length of string behind them, the use of which will appear hereafter. There are several ways of tuning the Koto, but in the Japanese Village, the *hiradio-shi* alone was known. Of the 13 strings, only 5 give different notes, the remainder are unisons, or Octaves of these. It is, therefore, only necessary to consider the first 7 strings, of which the fifth is in unison with the first, and the seventh is the octave of the second. The scale is comprised between the second and seventh strings, and for convenience I reckoned from the second, or lowest note, which Mr. ——— considers to be the fundamental tone.

Mr. Isawa's Report..	I	702	II	204	III	112	IV	386	V	112	VI	386	VII
Sums....	702		0		204		316		702		814		1200
Female Player.......	I	719	II	193	III	164	IV	362	V	82	VI	398	VII
Sums........	719		0		193		357		719		801		1199
Music Master........	I	683	II	185	III	152	IV	346	V	107	VI	410	VII
	683		0		185		337		683		790		1200

Now these show great discrepancies, and those between the woman and her master are curious, for the woman used a sharp and the man a flat Fifth (with 36 cents between them). But both seemed to aim at a Semitone and a major Third as the final intervals, and at a Tone (almost a minor Tone with the man) to begin with (II to III). So far they agree in intention with Mr. Isawa. But the next two intervals in his report are 112 and 386, while the woman had 164 and 362, and the man 152 and 346 cents. The sums of these pairs of intervals are 498, 526, and 498 cents, respectively, so that the second pair (the woman's) must have been in error. But is it possible that the intervals were all meant for 112 and 386? Or were the last two intended for 150 and 350, two intervals of the 24 division being $\frac{3}{4}$ and $\frac{7}{4}$ tone? Mr. ——— has never heard of such intervals. He thinks the player may have hit on them unconsciously. That would imply that he aimed at 112 and 386, but did not succeed. That, however, they were not accidents of the moment was shown by the fact that the man reproduced the same intervals on his Siamisen (as was proved by my forks), and he showed us marks on the fingerboard of that instrument which guided his fingers, though there were no frets. Moreover, in tuning Mr. Hipkins's Koto for the purpose of showing it this evening, it was treated in the same way, with the neutral Third of about 350 cents, IV to V, and no attempt at a major or minor Third, and a Semitone from V to VI. On this occasion the music master tuned his own Koto, and the lady teacher of the Siamisen tuned Mr. Hipkins's to it. Hence this method of tuning clearly exists, although not acknowledged by either Mr. Isawa, or, as we shall see, Mr. ———.

Mr. ——— agrees with Mr. Isawa's report, so far as strings I, II, III, V, and VII are concerned. He does not believe in tuning a major Third down from I or V to IV, although Mr. Isawa says in his letter that "the older style [of tuning] has really a natural major Third [386 cents] in an interval between IV and V in hiradio-shi." Mr. ——— agrees that there is something like the interval, but that it is obtained indirectly, by tuning III to IV and V to VI, "not by consonance, but by a certain melodical intuition," and admits that it is "as nearly as possible a diatonic semitone," though "it is impossible to pronounce it so, as even the ablest musicians do not always give precisely the same tones when required to tune separately. It is important," he adds, "to remark that the

interval IV to V and VI to VII are *not* tuned by major Thirds, to which they are very nearly equal. I rather doubt whether the Japanese have an idea of the perfect consonance of the Third, and so of the Sixth. They use generally the Octave, the Fifth and the Fourth in tuning." We may, therefore, probably assume that the two tunings of the woman and her master resulted only from their having taken bad shots at the Semitones, the major Thirds being left to shift for themselves. It is interesting to observe that this hiradio-shi scale, which consists of a tone and two conjunct tetrachords, each divided approximately into a Semitone, and its defect from a Fourth, presents us with a survival of the oldest Greek tetrachord. Perhaps Olympos himself tuned no better, and it is only theorists who have rendered his intervals exact, precisely as Mr. Isawa, in his praiseworthy efforts to raise Japanese music, has defined the intervals with a mathematical precision, which the ordinary musician, whether Japanese or European, fails to appreciate. I know in England the extreme difficulty of getting a major Third exactly tuned, and am not surprised that the same difficulty occurs in Japan.

The above discussion has been given at considerable length; not only because it is interesting and novel in itself, but because it serves to explain many similar confusions recorded above. For what follows, then, I shall assume the equal temperament as sufficiently correct. "I can assure you," says Mr. ——, "that when you play any Japanese air on the piano, no Japanese musician will pronounce it wrong."

There were 12 popular tunings of the Koto, which were given, in staff notation, on charts at the Health Exhibition of 1884. We may now write them thus, using *c c' c''* to indicate the tenor *c* on the second space of the bass, *c'* the Octave above it, or middle *c'*, and *c''* the Octave above the last, or treble *c''* respectively, and omitting or adding accents in a similar manner to the names of all the notes in the Octaves beginning with *c, c', c''*. The notes in ( ) constitute the pentatonic scales to be considered. As equal temperament is adopted; the number of equal Semitones between the notes are, for brevity, used in place of cents. The Japanese name is prefixed.

1. Hira-dioshi:—
   d (g 2 a 1 b fl 4 d' 1 e' fl 4 g') a' b fl d'' e'' fl g'' a''.

2. Akebono I:—
   d (g 2 a 1 b fl 4 d' 2 e' 3 g') a' b' fl d'' e'' g'' a''.

3. Akebono II: –
   d' g 2 (a 1 b fl 4 d' 2 e' 1 f 4 a') b' fl d'' e'' f'' a'', which contains an extra note *g*, not having any Octave in the pentatonic part.

4. Kumoi I.:—
   d' (g 1 a fl 4 c' 2 d' 1 e' fl 4 g') a' fl c'' d'' e'' fl g'' a'' fl.

5. Kumoi II.:—
   d' (g 1 a fl 4 c' 2 d' 1 e' fl 4 g') a' fl c'' d'' e'' fl g'' a'', which differs from 4 only in having an extra note *a''* on the 13th string.

6. Han-Kumoi (*i.e.*, a variant of Kumoi):—
   d' (g 2 a 3 c' 2 d' 1 e' fl 4 g') a' c'' d'' e'' fl g'' a'', which differs from 5 in having *a, a'* for *a* fl, *a'* fl.

7. Kata-Kumoi:—
   d' (g 2 a 1 b fl 4 d' 1 e' fl 4 (g') 1 a' fl 4 c'' 2 d'' 1 e' fl 4 g'') a''. This has two different pentatonic scales, *g'* ending the first, and beginning the second. The first is the same as No. 1, and the second the same as No. 5, including even the final *a''*.

8. Sakura:—
   d' (g 1 a fl 4 c' 2 d' 1 e' fl 4 g') a' fl c'' d'' e'' fl g'', c''.

9. Iwato:—
   c' (g 1 a fl 4 c' 1 d' fl 4 f' 2 g') a' fl c'' d'' fl f'' g'' c'''.

10. Han-Iwato:—
    d' (g 1 a fl 4 c' 2 d' 3 f' 2 g') a' fl c'' d'' f'' g'' a''; this has *d'* for *d'* fl in 9.

11. Kata-Iwato:—
    d' (g 1 a fl 4 c' 1 d' fl 4 f' 2 (g') 1 a' fl 4 c'' 2 d' 1 e'' fl 4 g'') a. This, like 7, contains two pentatonic scales, the first ending and the second beginning with *g'*. The first is the same as No. 9 and the second as No. 8.

12. Kumoi-Hen:—
    d' (g 1 a fl 4 c' 2 d' 1 e' fl 4 g') a' fl c'' d'' e'' fl g'', a''. This seems to be precisely the same as 5.

Now, these scales seem to imply the existence of a pentatonic system and that only. But this would be an error, for the Koto player, by pressing upon the string behind the bridge, can easily raise the pitch of any note, either slightly or as much as half a tone,* and in

* Mr. —— says, "usually IV and VI," this would change the division of the tetrachords in pentatonic *hiradio-shi*, from a Semitone and a major Third to a Tone and a minor Third, and thus reduce it to a usual form (No. 3 of Section XII), but not render the scale heptatonic. To get Mr. Isawa's classical Riosen scale, given presently, we should require first that the original tuning should be what is thus obtained, II 200 III 200 IV 300 V 200 VI 300 VII, and nex that IV & VI should be raised a whole Tone, as Mr. ——

point of fact he is constantly manipulating the strings in this way with his left hand, to an extent which seems to suit the fancy of the moment. "The amount of raising is rather obscure, as it depends on the degree of pressure. Sometimes we flatten the notes by pulling the string on its other part than that plucked," that is, I suppose, practically raising the string from the bridge, and for the moment making a new bridge of the finger, thus lengthening, and therefore flattening, the string. (This flattening was also noticed by Dr. Veeder.) Mr. —— therefore hesitates about saying that the Japanese scale is pentatonic. "The two complementary tones are not due to modern addition, but are insignificant from having no representation on the Koto. With our musicians, this is not of much interest, as they do not greatly care about the construction of scales. These complementary tones play no important *rôle*, but are generally used as passing tones of a melody"—a circumstance which seems to show the original pentatonic construction of the scale, as has been remarked in so many Scotch airs. Mr. Isawa appears to assume a pentatonic origin derived from the original five Chinese notes or *Gosei*. There seem to be two entirely different kinds of music—the classical and the popular. Of the classical, or "old Chinese school," as Mr. —— calls it, he says it "is only played in the Imperial household, or Shinto temples, and is entirely unappreciated by the whole people. It, therefore, does not contribute anything towards the musical cultivation, or towards the pleasures of the people." Mr. Isawa's report distinguished strictly between them. The preceding Koto tunings are all popular. In the classical, two forms of scale are distinguished — Riosen (corresponding to, but also not identical with, our major scale) and Ritsusen (corresponding to, but also not identical with, our minor scale). The notes marked (*) are considered as variable; that is, no doubt, produced by pressure on the strings beyond the bridge. I give notes and intervals as before—

CLASSICAL RIOSEN.

Names..........	kin		sho		kaku		*henchi		chi		oo		*henkin		kin
	D	2	*E*	2	*F* sh	2	*G* sh	1	*A*	2	*B*	2	*c* sh	1	*d*

CLASSICAL RITSUSEN.

Names..........	kin		sho		*ei sho		kaku		chi		oo		*ee oo		kin
	D	2	*E*	1	*F*	2	*G*		*A*	2	*B*	1	*c*	2	*d*

These differ from European *D* major, by having *G* sh for *G* (but *G* is generally used in descending, at least, sometimes), and from European *D* minor (descending form) by having *B* for *B* fl. Observe that Riosen is the Greek *F*-mode, and Ritsusen the Greek *D*-mode. Mr. Isawa gives 4 Riosen and 3 Ritsusen Koto tunings, all classical, and having this peculiarity that their tetrachords consist of a Tone and a minor Third, and not, as in the popular case, of a Semitone and a major Third.

Ichikotsu-Chio (Riosen).

d' d' (*a* 2 *b* 3 *d'* 2 *e'* 2 f' sh 3 *a'*) *b' d'' e'' f''* sh *a''*

L io Dio (Ritsusen).

b' (*e'* 2 *f'* sh 3 *a'* 2 *b'* 2 *c''* sh 3 *e''*) *f* sh *a'' b'' c'''* sh *e''' f'''* sh.

Thus taking one example of each.

It is remarkable, that although these two scales have different pitches, and are differently classed, the intervals in the pentatonic part in parenthesis are identical.

Mr. Isawa also gives two popular heptatonic scales.

I. *D* 1 *E* fl 2 *F* 2 *G* 2 *A* 1 *B* fl 2 *C* 2 *d*.

II. *D* 1 *E* fl 2 *F* 2 *G* 1 *A* fl 2 B fl 2 *C* 2 *d*.

These differ from each other only in the Fifths, which reduces to a Tritone in II. Observe that I is the Greek *E* mode, and II is the Greek *B*-mode (see Sect. V.). Mr. Isawa says "there is no scale in the Japanese classical or popular music which is not found in the scales of Greek music;" that is to say, when the Japanese intervals have been rendered precise.

The next important instrument to the *Koto* is the *Siamisen* (Isawa) or *Shamisen* (———), a long-necked guitar, or tamboura, with three strings and no frets, often played with the

observes, but does not seem to have met with. After reducing the tetrachord to this form, however, we could, by sharpening IV and VI by a Semitone where necessary, obtain a real heptatonic scale, II 200 III 200 IV 100 IV sh 200 V 200 VI 100 VI sh 200 VII, the Greek *G*-mode (Section V), which, however, does not seem to be known in Japan.

Koto, already referred to. The three strings are tuned in three ways:—1. *honcho sai*, *D G d*, an Octave with a Fourth inserted; 2. *niagari*, *D A d*, an Octave with a Fifth inserted; and 3. *sansagari*, *D G c*, giving two Fourths. These were well tuned at the Japanese Village. Having no frets, it could follow all the alterations of the Koto.

The Biwa, already mentioned, is simply a classical instrument, and its four strings are tuned in six ways: —3 riosen (open strings, as *a d' e' a'*, or *g a d' g'*, or *a b e' a*), and 3 ritsusen (open strings, as *e b c' a'*, or *a c' e' a'*, *or f* sh *b e' a'*), so that nearly any Semitones could be taken. The charts of Mr. Isawa also described (1) the *Riuteki fuye*, or transverse flute, with a scale given as *D d* sh *E F* sh *G A B c c* sh; (2) the *siaku hachi*, or vertical flute, with a scale given as *D F E D* sh *G F* sh *G* sh *A c b a* sh *c* sh *d*, in this order; (3) the *hichi riki*, or oboe, with the scale, *G A B c d e f* sh *g a*. All, therefore, have a pentatonic scale and additional notes.

Mr. Isawa distinctly claims a species of harmony for Japan, and gives an arrangement of the Greek "Hymn to Apollo" (Chappell, p. 174), which he had directed "a Court musician, and a member of the [Musical] Institute [at Tokio] to harmonise purely according to the principles of Japanese classical music." It was set for 5 instruments, the Riuteki (fuye), Hichiriki, Sho, Koto, and Biwa. I have seen the setting. Though much was in Octaves, the Koto played a figured form, with dissonances, followed by consonances. Mr. —— says, "anything like European [harmony] cannot be heard in Japan. If it exist, it is of the rudest possible description. We have certainly *ensemble* playing with many instruments of different sorts; but it seems to me that we have no idea of such things as chords. . . . . We go generally parallel in Octaves and in Fifths, rarely in Fourths, but there are cases where two different tones, not belonging to the three consonances, are sounded, but they are not *harmonic*, but what Helmholtz calls *polyphonic*. We have many *figures* for accompaniment. . . . . In popular music, we meet with cases where two instruments play Octaves or Fifths. With singing this would also hold, but it is very rare that people ever sing chorus."

My warmest thanks are due to Mr. ———, for his very important remarks on Japanese music, and to Mr. Isawa, for his connected exposition and his letter. Together they have enabled me to give an entirely novel, though still incomplete, account of Japanese music. In conclusion, I am sure that all will heartily join in wishing success to the infant Musical Institute at Tokio in improving and extending Japanese music, under the leadership of its able director, Mr. S. Isawa.

XVI.—Conclusion.

In this hasty review of the musical scales of some of the principal and some of the minor nations of the world, we find the following facts. First, the relation of the Octave, naturally given by the voices of boys and men, is naturally recognised, although not always correctly tuned on the instruments examined. At this we must not be surprised, for it is often incorrectly tuned even on modern pianos. The next interval most generally appreciated is the Fourth. All Greek music, and hence all modern European, as well as all old and medieval music, is founded on this interval. The Fifth seems to have been rather appreciated as the defect of the Fourth from the Octave, though modern tuners find the Fifth much easier to appreciate than the Fourth. The Tone was appreciated only as the difference between two Fourths and the Octave, or between a Fourth and a Fifth. But, in very early times, in the tetrachord of Olympos, the just major Third of 386 cents made its appearance, and with it the just diatonic Semitone of 112 cents, as the difference between it and a Fourth. Unless, indeed, as in Japan, the Semitone was tuned by a kind of guess, and the major Third obtained as the defect from a Fourth, and this seems to be a very likely hypothesis. At any rate these intervals (assumed by Helmholtz as 15 : 16, or 112 cents, and 4 : 5, or 386 cents) were soon ousted by the strict system of Fourths, on which the later Greek scale was formed.

In Arabia and Persia, however, other distinctions came in. The old division of the Fourth into *C D E*fl *E F* was disliked, the *E*fl of 294 cents from *C* was felt to be too flat. The Persians raised it to 303 cents, as nearly as possible to our equally tempered minor Third, but retained the old *E* 408 cents. The division was then practically our equal one of 0 100 200 300 400 500 cents. But there was a lutist called Zalzal, who evidently disliked these 300 and 400 cents, and introduced the halfway-house or neutral 355 cents, where the ear is unable to determine whether the interval is major or minor. This practically employed

the trumpet scale 8 : 9 : 10 : 11 : 12, for 10 : 11 is 167 cents, and 11 : 12 is 151 cents. An entirely new interval was thus introduced, and seems to have struck deep root, the interval of three-quarters of a Tone. The medieval Arabic system drove it out of classical musical scales, by continuing the number of Fourths to 16, using therefore 17 notes, which gave very artificial scales, generally bordering on the old Greek, but often greatly diverging from them, occasionally employing even eight notes in a scale. The later Arabic forms, by dividing the Octave into 24 equal Quartertones, sufficiently reconciled Zalzal and the medieval musicians. But the normal scale was Zalzal's of 0 200 350 500 700 850 1000 1200 cents, and this scale we imported into England, and still possess in the Highland bagpipe, which has not yet been harmonised. The attempt, however, to conform to the other Arabic scales led to sharpening or flattening any of these notes by a quarter of a Tone, which was one of their degrees. thus producing a large number of varieties.

Now did India draw upon Arabia, or conversely? In India we have a remarkably complex system. First a scale very like our major, but with a sharpened Sixth of 906 in place of 884 cents There was consequently a separation of the scalar intervals into three kinds, major, minor, and half Tones, and these were supposed to be divided into four, three and two equal parts respectively, which I have called degrees. Practically these, being produced by shifting frets, pressing on strings behind the fret, or deflecting them along the edge of the fret, were never precise, but were always about or slightly exceeding a quarter of a Tone. Then came the habit of altering the intervals by a degree, which is extremely like the Arabic Quartertone system; although it must have been generated independently, yet it certainly frequently produced in the different modes, and modelets, those three-quarter Tones which in Arabic music we owe to Zalzal.

China and Japan introduced nothing new beyond the original limitation of the scale to five notes, which arose in fact from the divisions of tetrachords into two parts only, for example, a Semitone and major Third, like those of Olympos, whose very division we find in the popular music of Japan, or else into a Tone and a minor Third, the Thirds arising in each case as defects of the first intervals from a Fourth. Such tetrachords were then either conjunct or disjunct. But they were always capable of being completed into Greek scales, as has been actually done in Japan, and possibly in China. On the instruments as tuned or played by natives, China offers many examples of the three-quarter Tone interval. But neither China nor Japan, any more than Europe, have reached the complete Quartertone system, which we find in Arabia and practically in India. On the other hand, Japan at least, and China also, according to Amiot, have attained to a system of twelve, more or less exact, equal Semitones.

The double pentatonic system, as developed in Java, is, however, something new and entirely different from the Chinese and Japanese. The first system seems to be formed by taking the Fourth flat enough to give, practically, a division of the Octaves into five equal Pentatones. Remarkably enough, the fourth note of the scale thus becomes very nearly indeed the natural harmonic Seventh of the first note. But upon this system, if I am correct, both Fourth and Fifth are defective, the Fourth being flat, and the Fifth sharp. Whatever be the theory of the scale, this fact is certain, and it entirely destroys the assumption of the necessity of founding a scale upon the Fourth or Fifth. This is further confirmed by the second class of pentatonic scales in Java, for which I have not been able to find any satisfactory principle, although they adopt intervals of very nearly 100, 150, and 300 cents, that is nearly Semitones, three-quarter Tones, and minor Thirds. This system has a fund of seven notes to the octave, and out of this fund it selects different sets of five to form a scale. Whereas, then, in the first system no interval between consecutive notes is so small as a Tone, or so large as a minor Third; in the second system, differences of 100, 150 (rarely or never 200), 300, 400, 450, and even 550 cents occur. The first set of scales are therefore remarkably uniform, the second as remarkably diverse. Another singular difference is that in the first system the Fourth is flat, and the Fifth sharp; but in the second the Fourth is very sharp, almost a Tritone, and the Fifth is nearly a comma flat. In the first system, and on at least two scales of the second (Dangsoe and Bem), the harmonic Seventh is developed.

The final conclusion is that the Musical Scale is not one, not "natural," nor even founded necessarily on the laws of the constitution of musical sound, so beautifully worked out by Helmholtz, but very diverse, very artificial, and very capricious. At the same time

the contributions I have been able to offer towards the study of this vast subject, are, notwithstanding the inordinate length of my paper, relatively very small and manifestly extremely imperfect in observations. They really require completion by the long and careful observation and study of many physicists who have some notion of music, rather than of musicians whose ears are trained to particular systems with but slight knowledge of physics. At my time of life I must feel satisfied with having shown that such an investigation is possible.

The CHAIRMAN said that it was his pleasing duty to propose a hearty vote of thanks to Mr. Ellis for the most interesting communication he had made, which would repay the greatest amount of study when published in full, and even the short *resumé* just given showed what an immense amount of research Mr. Ellis had devoted to the subject. They could only hope that he would still have much time and opportunity before him to pursue this subject, which was evidently to him, one of increasing interest. He hoped that in the musical department of the forthcoming Inventions Exhibition there would be opportunities for judging of the scales of different nations, as illustrated by their different instruments. The Siamese would, he knew, be represented by an efficient band, and probably there would be some others.

The vote of thanks was carried unanimously, and the proceedings terminated.

Miscellaneous.

SILKWORMS OF ASSAM.

The following particulars are obtained from a Report on Silk in Assam by Mr. E. Stack, Director of Agriculture in Assam, which contains a complete description and account of the rearing of three domesticated silkworms, two of which have been erroneously considered by English silk-spinners as wild silkworms; these are the *Muga* and *Eri*, which, although they may, like other species, be found in a wild state, are not found in sufficient quantities to be called wild silkworms of Assam; they are cultivated worms.

The wild silkworms of Assam occur so sparingly, that no silk could be supplied in large quantities from the collecting of the cocoons. Silks in Assam are, therefore, obtained by the cultivation of three domesticated worms, and not from the wild silkworms. Mr. E. Stack says that in treating of the silks of Assam it is desirable to make it clear that, from the wild silkworms of Assam, as they now exist, nothing whatever is to be expected, and that it is very doubtful whether by the most strennous efforts one hundred weight of wild cocoons of all sorts could be collected in the whole of the Assam valley.

Domesticated Silkworms of Assam.—There are three kinds of domesticated silkworms in Assam. These are the *Pát*, or mulberry worm (*Bombyx textor*); the *Muga*, or *sum*-feeding worm (*Antheræa assama*) whose cocoon, like that of the *Pát*, can be reeled; and the castor-oil worm (*Attacus ricini*), yielding a silk which is spun by hand.

Pát, or mulberry silkworm.—Of this there are two species cultivated in Assam; the univoltine *Bombyx textor*, called *bor polu*, or large worm, and the multivoltine *horn polu*, or small worm, *Bombyx cræsi*. Both species are reared indoors on the leaves of the mulberry (*Morus indiça*).

Attacus recini.—*Eri* worm, or *Attacus ricini.* This is reared principally on the castor-oil plant (*Ricinus communis*), called *eri* in Assamese, but it feeds also on the *Keseru* (*Heteropanax fragans*), and there are several other trees, as *gulancha* (*Jatropha curcas*), the *gomári* (*Gmelina arborea*), and even it is said, the common *bogri* or *ber* tree (*Zizphus jujuba*), which the worm can thrive on in its later stages, if other food is not procurable in sufficient quantity. The *Eri* worm is multivoltine, and is reared entirely indoors, and as many as eight broods can be obtained in twelve months. Large numbers of worms are lost by disease during these indoor rearings, which is not to be wondered at, as the excreta and even the dead worms are not removed. The *Eri* worm is cultivated, to a greater or less extent, in every district of the province of Assam.

The number of moultings of the *Eri* worm is four, and the following description of it is given by Mr. Thomas Hugon in a paper which he contributed to the Proceedings of the Asiatic Society of Bengal for 1837:—"The caterpillar is first about a quarter of an inch long, and appears nearly black. The colour is, perhaps, more exactly described as a blackish-yellow. As it increases in size, it becomes of an orange colour, with six black spots on each of the twelve rings which form its body. The head, claws, and holders are black; after the second moulting, they change to an orange colour; that of the body gradually becomes lighter, in some approaching to white, in others to green, and the black spots gradually become the colour of the body. After the fourth or last moulting, the colour is a dirty white, or a dark green. On attaining its full size, the worm is about $3\frac{1}{2}$ inches long." According to one series of observations, it would appear that in the hot months, the first change of skin occurs three days after hatching, and the rest follow at intervals of three days, while the worm begins to spin on the fourth day after the final change, or the fifteenth day after hatching. In the cooler months, the period between each moulting is four or five days, making twenty to twenty-five

days between hatching and beginning to spin; and in the winter season, the worm lives a whole month, or even longer.

The *Muga* worm or *Antheræa Assamœa (A. Assamensis)*.—The scientific name of the *Muga* silkworm denotes its peculiar connection with Assam, and in fact it is found in no other part of India except Dehra Doon, where it occurs sparingly. Its Assamese name, *muga*, is said to be derived from the amber colour of the silk, and is frequently used to denote silk in general, so that *Eri muga* means eri silk, *Kutkuri muga* tusser silk, and so on; the genuine *muga* being distinguished by the title of *Sompatia muga*, or silk yielded by the worm that feeds on the *sum* leaf. It is a multivoltine worm, and is commonly said to be semi-domesticated, because it is reared upon trees in the open air; but in fact it is as much domesticated as any other species, being hatched indoors, while during its life on the tree it is entirely dependent on the cultivator for protection from its numerous enemies. The *sum* tree (*Machilus odoratissima*) furnishes its favourite food; but in Lower Assam it is extensively bred on the *sudlu* (*Tetranthera monopetala*). The leaves of certain other forest trees—the *dighlati* (*Tet. glauca*), the *pátichanda* (*Cinn. obtusifolium*), and the *bamroti* (*Symplocos grandiflora*)—can be eaten by the worm in its maturer stages if the supply of its staple food begins to fail; but the *sum* and the *sudlu* are the only trees upon which the worm yielding the ordinary *muga* silk (as distinguished from *champa* and *mezankuri*) can be permanently reared. The *sum*-fed worm is considered to yield the most delicate silk, and *sudlu* trees on the edges of *sum* plantations are generally left untouched, though small plantations of *sudlu* only may occasionally be met with.

Five successive broods of the *Muga* worm are obtained, but it is only in a few parts of the Assam Valley that this regular succession of broods is maintained. The worm is said to degenerate if bred all the year round in Upper Assam, and the rearing is discontinued in the summer, another reason for doing so being that the *sum* forests are at that time flooded by the rains, therefore the breeders of Upper Assam generally go down to Kámrúp or Nowgong to buy breeding cocoons at the beginning of the cold season. The period from hatching to maturity varies from twenty-six days in summer to forty days in winter. The *Muga* cocoon is in size about $1\frac{3}{4}$ inch long by 1 inch in diameter. In colour it is a golden yellow, but there are usually a number of dark cocoons in every brood. The silk of the cocoon is reeled, but no part of it is rejected as useless; the floss plucked off before reeling, the silk of the shell, and that of the open cocoons, are spun by hand into a coarser thread, which is mixed with *Eri* thread, or is woven by itself into warm and durable fabrics.

There are two varieties of the *Muga* assumed by it when the worm is fed on the *champa* (or more properly *chapa*) and the *mezankuri*, or *adakuri* (*Tetranthera polyantha*). *Champa* silk seems to be quite forgotten now. It is described as a very fine white silk, which used to be worn only by the Ahom Kings and their nobles. *Mezankuri* silk is still to be procured, but with great difficulty. In 1881, there does not seem to have been a single piece obtainable in Jorhát. One of the reasons alleged for this falling off is that the new rules restricting clearances of the forests are unfavourable to the growth of the *mezankuri* tree. This tree springs up spontaneously in abandoned clearances, and it is in this early shrub-like stage that it is fit for the worms to feed on. In its second year, the worms fed on it give coarser silk; in the third year, the silk is hardly distinguishable from the common *muga*. Thus the mature tree is quite out of the question, and as the *mezankuri* is never cultivated, forest clearances are the only places where the breeders could look for young trees. When fed on the *mezankuri*, the *Muga* worm spins a fine silk of almost a pure white, about thrice as valuable as the common *muga*, in fact the most costly of all the silks in Assam. The silk is altogether an article of luxury.

Wild Silkworms.

1. *Ban muga* (*Antheræa Assama*), or forest *Muga*, is simply the common *Muga* worm in its wild stage. The cocoons are not plentiful enough to be largely used, but the wild moth is sometimes allowed to improve the strain of the domestic breed.

2. *Attacus cynthia*.—The wild *Attacus cynthia* is closely allied to the *Eri* worm, and in some cases is regarded as the *Eri* in its wild state. It appears to be commonest in Cachar, but it is also known in Kámrúp.

3. *Petogore muga* (*Attacus atlas*).—The *Petogore* silkworm feeds on the *kutkuri* (*Vanqueria spinosa*), the word *muga* being added to its name in the generic signification of silkworm. It is rare in the Assam valley, but common enough in Cachar. It is said to be easily capable of domestication.

4. *Wild Pát Worm*.—There is a wild silkworm of the *pát* species, which is found on banyan trees (*Ficus indica*), and is sometimes taken and reared by Jugis on mulberry leaves, like the domesticated worm, to which it becomes thoroughly assimilated in the course of three generations. The worms are evidently of the smaller, or multivoltine, kind. It is not certain whether the larger kind are found in the wild state.

5. *Assamese tusser* (*Kutkuri, Antheræa paphia*).—The silkworm called the *Kutkuri* is believed to be the same as the common *Tusser* of Bengal. Its food is principally the *kutkuri* (*Vanqueria spinosa*) from which it takes its name, or else the plant called (erroneously) the wild rhododendron (*Melastoma malabatricum*), the Assamese name of which is *phutuka*. It has been cultivated in the palmy days of the Assam silk industry, but it is now almost entirely neglected, as being inferior to *Muga*, and also, perhaps, because it only yields three broods in the year. It is common in Jorhát and Cachar. The *phutuka* being one of the commonest wild shrubs in

Assam, the *Kutkuri* worm could probably be cultivated at little cost, but the silk could not compete with the cheaper and better tusser supplied by Bengal.

Another worm, which appears to be simply a variety of the *Tusser*, feeding on the *phutuka* like the worm above-mentioned, is counted by the Assamese as a distinct species, and known by the name of *Deomuga*. It must not be confounded with the genuine *Deomuga* described further on. From cocoons of this so-called *Deomuga*, boiled in potash water for two hours, a fine thread, resembling that of the *Muga*, was reeled off.

6. The *Salthi* (*Antheræa paphia*).—The wild silkworm called *Salthi* is also a species of *Tusser*. It is called *Deomuga* by the Kacháris, but must not be confounded with the *Deomuga* proper. The *Salthi* worm feeds on the *kamranga* (*Barringtonia racemosa*), and the *hidal*. The worm is very rarely met with; its habitat is the jungle at the foot of the Bhutan Himalayas. The chrysalis of this species, as of all the wild silkworms, is eaten with much relish by the Kacháris.

7. The *Amluri* or *Ampotoni* (*Cricula trifenestrata*).—The *Amluri* or *Ampotoni*, so-called from the mango or ám tree on which it feeds, is one of the commonest wild silkworms of Assam. It occurs in the Assam valley, under both the northern and the southern hills, and likewise in Cachar, where the wild tea-plant often supplies it with food. It is also frequently found on *sum* trees Its favourite tree, however, is the mango, whether the wild mango of the forest, or the cultivated trees in the vicinity of villages. The *Amluri* spins a bright yellow cocoon, in clusters so closely interwoven that they cannot be separated for reeling, which, indeed, their very texture prohibits. In the number of broods and times of breeding this worm is said to correspond with the *Muga*. The worm is covered with hairs, which produce irritation of the skin, and for this reason it is regarded as unclean by the Hindus; but Kacháris, Rábhas, and Meches occasionally mix the silk with the *eri*, where it reveals its presence by the itching it causes; this irritating property of the worm is said to protect it against crows and bats. The chrysalis, however, is eaten by Kacháris, Rábhas, Mechas, and Mikirs. A smaller variety of the *Amulari*, called *Bisha*, and feeding, like the *Amluri*, on the mango tree, is found in small numbers in the Sub-Himalayan jungles of Kámrúp. The name expresses the irritating quality of the worm.

[In the rearings which have been made in 1884, for the first time in Europe, of *Cricula trifenestrata*, no notice has been taken of the irritation caused by the hairs of the larva.—A.W.]

8. *Deomuga* (*Bombyx religiosæ*).—The *Deomuga* silkworm is so called from its size. It is the largest of all the worms, attaining a length of 6½ inches, and it is also the handsomest. Mr. Buckingham writes:—"This worm appears at times on *sum* trees with the *Muga*, but it is of rare occurrence. The worm in its second and third stage is particularly handsome, with rows of turquoise spots on its side. When the worm enters upon its fourth stage, the turquoise spots vanish, and spots of gold appear in their place, and on each side of the body stripes, having all the colours of the rainbow, tend to make this worm by far the most beautiful of its tribe." The *Deomuga* worm is said to live thirty days, and to spend three days in spinning its cocoon; the period of the chrysalis is fifteen days in the hot, and thirty days in the cold season, and the life of the moth lasts about four days. The cocoon is large (3 in. by 1½ in), and gives a large quantity of strong but coarse and dark-coloured silk. The hardness of the cocoon renders it difficult to reel, and the silk easily gets into knots. The thread of the *Deomuga* is said to be used for fishing lines in Bengal. In Cachar, the *Deomuga* feeds on the banyan (*Ficus indica*) and pipal (*Ficus religiosa*). The worm occurs generally in the Assam valley.

9. *Actias Selene*.—This silkworm occurs in Cachar but very rarely. The cocoon yields but little silk, and no attempt is ever made to use it.

COAL MINES OF FORMOSA.

The following particulars respecting the working of the coal-fields at Kelung, in the island of Formosa, which were opened up in consequence of the establishment of the Naval Arsenal at Foochow, are extracted from an article by Lieut. the Hon. Henry N. Shore, R.N., in the *Army and Navy Magazine*:—

The coal which has been obtained hitherto, although of a bituminous nature, and, therefore, rather quick-burning for steam purposes, had been exclusively used in the Foochow Arsenal, as well as by coasting steamers; and it was thought that by means of machinery, and proper methods of working, coal of a superior quality to what had hitherto been obtained might be placed in the market, so as to compete, at Shanghai and Hong-kong, with the Japanese coal. We shall see how far these anticipations have been realised.

It was necessary, in the first place, to protect the "foreign devils"—as Europeans are playfully called by the Chinese—from molestation, and with that object a mandarin was sent to reside on the spot, whilst proclamations were distributed, cautioning the natives not to interfere with the miners. These precautions were hardly necessary, however, for the antipathy to foreigners which is so marked a characteristic of the Chinese in their own country, is much less noticeable in Formosa, where, probably owing to the freedom of the colonists from the influence of the literary and official classes, they rarely insult or molest Europeans.

In the Consular Reports for the year 1880, Mr. Ford, acting Consul for the port of Tamsui and Kelung, makes the following observations with

regard to the export of coal:—"The working of the Government mine, so far as Mr. Tyzack, the mining engineer in charge, is able to control it, reflects great credit on that gentleman; and it is only because he has been so often thwarted by the indifference, and sometimes by the active opposition, of the Chinese officials connected with the mine, that the undertaking has so far been a losing instead of a prosperous one. The output during 1879 was 30,046 tons, nearly double that of the previous years; but so shortsighted was the policy of the Chinese officials concerned, that, at the end of the year, over 10,500 tons of the year's output was still in the yards, and yet they complained that they could not dispose of the coal. Latterly, I believe, prices have been placed periodically on the different varieties of mine produce, but I am assured that foreign merchants can never obtain the coal at those prices. At the beginning of the year (1879) the prices for the Government coal were, at the yard, screened, \$21 per 100 piculs; nuts, \$10. Prices for the best coal obtainable from private native mines ranged from \$18 to \$15 per 100 piculs. Towards the end of the year, the officials became suddenly more energetic, and, workers being supplied in large numbers, the output was very materially increased, and for the first time the estimated 200 tons in a day was reached, and during the month of January of the year 1880, 4,700 tons were raised from the mine. Unless, however, the authorities make satisfactory arrangements for putting the coal on the market at reasonable prices, the only result of this increased output will be the choking up of the coal-yards, which are well stocked already, and an increased risk of loss from fire and from deterioration of the coal."

These remarks were amply justified. The authorities persisted in adhering to their suicidal policy in regard to prices, and, as the natural result, the coal trade steadily declined, the exports for the year 1880 being 24,654 tons against 28,823 in 1879. The Government mine began to suffer, moreover, from the effects of competition, and, with a view of keeping up their own high prices, it was stated that the officials endeavoured to have all the private mines closed. Towards the end of 1880 a change took place, with reference to which a Hong-kong paper remarked as follows:—"It is satisfactory to learn that the period of official obstruction seems likely to come to an end at an early date. The engineer in charge now finds great facilities placed within his reach, and the work proceeds more smoothly than it has ever done yet, with the natural result that the produce of the mine is increasing at a steady rate of progression; 1,000 tons per week were early this year turned out, while the output has gone on increasing to 1,200 and 1,300 tons per week, and the hewers were taking greater pains to produce larger and more marketable pieces from the seam. The railway to the sea, and the other apparatus, were working in a manner which fully justified the expense incurred in their construction; and things generally are now assuming a more prosperous appearance than they have for several years. Luk Looey, the well-known native mandarin and merchant, is believed to have received instructions from head-quarters as to the more effectual development of the colliery works, and a great future is pictured by the well-wishers of the island of Formosa."

The immediate consequences of this change in the policy of the officials soon became apparent by the increased quantities of coal which were taken away from the island; indeed, during the latter part of the year, the demand for coal for foreign vessels was stated to have been in excess of the supply; and during the ensuing year of 1881 the returns showed an increase in the exports of 21,524 tons, or 46,178 tons in all. In addition to this, a large quantity was shipped in Chinese Government steamers direct from the mines for use at the Foochow Arsenal, and for the Chinese war-ships, for which no return was available.

The good results which have been attained so far were due, in the first instance, to the "enthusiastic and persevering devotion of the superintending engineer, Mr. Tyzack," and, secondly, to the appointment, during the year 1880, of the able Chinese official already mentioned, under whose auspices the mine became a successful commercial undertaking. In June, 1883, the last of the staff of foreign *employés* were discharged, the native officials, it is presumed, considering themselves competent to carry on the work without foreign help. The results seem to have been most unfortunate.

* Picul, $133\frac{1}{3}$ lbs.

Correspondence.

EXPLORATION.

I am glad to see that my remarks have elicited from Mr. Robinson the precise information I was anxious to obtain as to the use of the sextant in Australian exploration. The fact still remains that we have no universal instrument for explorers, and I believe a portable zenith-sector, constructed on the principle of the ex-Astronomer Royal's reflex zenith tube, so as to give latitude and sidereal time by one observation, will eventually supersede the sextant and all other instruments on *terra firma*. If some of our leading instrument makers would direct their attention to this desideratum, they would confer a great boon on explorers, and well deserve the "Fothergill" medal offered by the Society of Arts in the coming Exhibition.

JOHN BAILLIE,
Major-General.

4, Queensborough-terrace, W.,
March 25th.

Notes on Books.

Standard Practical Plumbing: being a Complete Encyclopædia for Practical Plumbers, and Guide for Architects, Builders, &c. By P. J. Davis. Vol. i. London: E. and F. N. Spon, 1885.

The author commences his work with an account of lead ores and their manipulation, and follows with a description of tin, from the ore as it is obtained, to the fine tin of commerce. Solder making, lead burning, and joint making, are then described. In treating of traps, the author has mentioned most of those that have been in use from the 12th century to the present time. Descriptions of cisterns, and of rain-water supply and storage follow. Different systems of ventilation are explained, and the whole system of soil pipes, drainage arrangements, waste pipes, and waste preventers are described. Acts of Parliament relating to water works and sanitary matters are given, and a series of examination questions for plumbers completes the volume, which is fully illustrated.

Simple Hydraulic Formulæ. By F. W. Stone. London: E. and F. N. Spon.

The formulæ here given for the use of the hydraulic engineer are described and explained, and also illustrated by a series of diagrams. The subjects specially treated on by the author are (1) flow of water over weirs, (2) discharge of water through orifices, (3) discharge through short tubes, (4) flow of water through long pipes and through distributing pipes in towns, (5) flow of water from jets, and heights attained by different diameters of jet, (6) on the flow of water through canals, rivers, aqueducts, &c., (7) special formulæ for miners and others engaged in sluicing, &c.

Obituary.

Sir Harry Parkes.—On Sunday morning, 22nd inst., Sir Harry Smith Parkes, G.C.M.G., K.C.B., British Minister to the Emperor of China, died at Pekin. Born in 1828, Harry Smith Parkes had become a Chinese scholar as well as resident at the early age of 15. In 1843, he was assistant to the Rev. Charles Gutzlaff, Chinese Secretary and Interpreter to Sir Henry Pottinger, the plenipotentiary, who negotiated at Nankin the first English treaty. His service in the far East extended, therefore, over a period of more than forty years, of which nearly twenty-five were passed in China, and the rest in Japan. From 1856 to 1858 he acted as Consul at Canton, and he was Commissioner at that place during the allied occupation 1858-61. In 1865, he was nominated Envoy Extraordinary and Minister Plenipotentiary and Consul-General in Japan, and in July, 1883, he was appointed Minister to the Emperor of China, and chief superintendent of British trade in China. Sir Harry Parkes was a member of the Society of Arts, and took the chair on the occasion of the reading of Mr. Gubbins's paper, on "The Principality of Loochoo" (May 31, 1881).

General Notes.

Pottery Exhibition at Delft.—The Delft Section of the Netherlands Society for the Promotion of Industry will open an International Exhibition at Delft, on the 1st June, 1885, to be devoted to Ceramic Tiles and Stained Glass. The Exhibition will remain open until 31st July. Applications for space must be made to the Secretary, at Delft, before the 15th of April, and exhibits must be delivered before the 15th May.

The Production of Silk in Russia.—According to a Russian industrial journal, the production of silk in the Turkestan district is more important even than in the Caucasus; the yearly outturn averaging rather over 500,000 lbs.; of which about two-thirds comes from the Sarawschansk district. Bokhara and Kashgar have, respectively, yearly crops of about 200,000 lbs. and 300,000 lbs. Silk cultivation has existed in Central Asia for seventeen centuries. In the first half of the second century, the Chinese possessed nearly all that territory; to which fact the starting of the industry has been attributed. Its present development would seem, however, mainly due to its revival, in 1875, by the governor of Bokhara. It is expected that the improved communications now being organised between Europe and Central Asia, will tend to open up direct trade in the raw material with the silk districts in question.

Chinese Minerals.—It appears from an official report published on the fossil and mineral products, &c., of the Ichang consular district of China —that there are three kinds of fossils produced in the district which are staples of trade, viz.: (1) Pagoda stones—*ethoceras;* (2) Kosmos stones—*ammonites;* and (3) stone swallows. The *ethoceras* found in slate at Nanchich-ah is cut, and is either framed as a picture or made into ornamental furniture. This is also the case when *ammonites,* which are called Kosmos stones, from their resemblance when polished to the Chinese symbol for Kosmos. As no duty is charged on the export of these fossils they do not appear in the trade returns. The third

kind of fossil, called by Chinese "stone swallows," is ground down and used as medicine. Coal is plentiful in the district; only when it is exactly suited to the native's requirements, or where the mine is favourably situated, is it worked to any extent. In many places the shafts are left open and coal extracted as people in the neighbourhood require it. Iron also exists almost all over the Ichang district; iron cauldrons and rude agricultural implements are, to a certain extent, exported thence in native vessels.

Swiss Standard Gold.—The Board of Trade have received, through the Secretary of State for Foreign Affairs, a copy of a despatch from Her Majesty's Legation at Berne, enclosing a decree of the Swiss Federal Council in regard to the control and warranty of manufactured articles of gold and silver. This decree provides that the standard designations marked at the Swiss Assay Offices on gold and silver work are to indicate in decimal fractions the degree of fineness of the metal as shown in the decree. For gold, however, there may be admitted the following carat marks:—18 "karats," or 72-18k., for the standard 0·750; 14 "karats," or 56-14k., for the standard 0·583. To facilitate the introduction in Switzerland of the decimial or millesimal marking, existing marks are also to be allowed until the 30th of June, 1885. Copies of the marks may be seen at the Harbour Department of the Board of Trade on any weekday between the hours of 12 and 4.

Royal Society of New South Wales.—Medals and money prizes are offered by the Royal Society of New South Wales, Sydney, for communications containing the results of original research or observation upon the subjects as given below. These are the continuation of the three series of former years. A Society's medal and £25 will be given for the best communication on each of the following subjects:—Series IV. (to be sent in not later than May 1st, 1885)—No. 13, Anatomy and Life History of the Echidna and Platypus; No. 14, Anatomy and Life History of Mollusca peculiar to Australia; No. 15, the Chemical Composition of the Products from the so-called Kerosene Shale of New South Wales. Series V. (to be sent in not later than May 1st, 1886)—No. 16, on the Chemistry of the Australian Gums and Resins; No. 17, on the Tin Deposits of New South Wales; No. 18, on the Iron Ore Deposits of New South Wales; No. 19, List of the Marine Fauna of Port Jackson, with descriptive notes; as to habits, distribution, &c. Series VI. (to be sent in not later than May 1st, 1887)—No. 20, on the Silver Ore Deposits of New South Wales; No. 21, Origin and Mode of Occurrence of Gold-bearing Veins and of the Associated Minerals. No. 22, Influence of the Australian Climate in Producing Modifications of Diseases; No. 23, on the Infusoria peculiar to Australia. The competition is in no way confined to members of the Society, nor to residents in Australia, but is open to all, without any restriction whatever, excepting that a prize will not be awarded to a member of the Council for the time being; neither will an award be made for a mere compilation, however meritorious in its way—the communication to be successful must be either wholly or in part the result of original observation or research on the part of the contributor. Competitors are requested to write on foolscap paper, on one side only. A motto must be used instead of the writer's name, and each paper must be accompanied by a sealed envelope bearing the motto outside and containing the writer's name and address inside.

MEETINGS OF THE SOCIETY.

Cantor Lectures.

Monday Evenings at Eight o'clock.

The Fifth Course, "Carving and Furniture." By J. Hungerford Pollen.

Lecture IV. March 30.—The Age of Gibbons, Boule, and that of their successors.

MEETINGS FOR THE ENSUING WEEK.

Monday, March 30...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures) Mr. J. Hungerford Pollen, "Carving and Furniture." (Lecture IV.)

Farmers' Club, Inns of Court Hotel, Holborn, W.C., 4 p.m. Mr. F. J. Lloyd, "Field Experiments."

Chemical, Burlington-house, W., 8 p.m. Anniversary Meeting for Election of Officers and Council.

East Indian Association, Exeter-hall, Strand, W., 2½ p.m. Mr. Robert Brown, "The Costliness of Indian Administration."

Tuesday, March 31...Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr. Peter William Willans' paper, "The Electric Regulation of the Speed of Steam-engines and of other Motors for Driving Dynamos."

Wednesday, April 1...Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m. 1. Mr. F. W. Passmore, "Note on an alleged Decomposition of Quinine in contact with Lime." 2. Mr. T. P. Blunt, "An Impurity in Distilled Water." 3. Messrs. W. Elborne and H. Wilson, "Proximate Analysis of Colubrina Redinata Bark." 4. Messrs. W. Elborne and H. Wilson, "Saccus Taraxaci."

Archæological Association, 32, Sackville-street, W., 8 p.m. Prof. Alfred C. Fryer, "Notes on Ancient Glass."

Thursday, April 2 Linnean, Burlington-house, W., 8 p.m. 1. Mr. Henry Groves, "The Coast Flora of Gapygia, South Italy." 2. Mr. Spencer Moore, "Studies in Vegetable Biology—Observations on the Continuity of Protoplasm; and on Rosanoff's Crystals in the Endosperm-cells of *Manihot, Glaziovii*."

Chemical, Burlington-house, W., 8 p.m.

Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Mrs. Sheil, "Physiology and the Laws of Health." (Lecture VI.). "Ventilation and Disinfection."

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FRIDAY, APRIL 3, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

INTERNATIONAL INVENTIONS EXHIBITION SEASON TICKETS.

The Executive Council of the International Inventions Exhibition have consented to allow Members of the Society of Arts the privilege of purchasing Season Tickets for the Exhibition at half-price (10s. 6d.) Any member desiring to avail himself of the privilege can obtain a ticket by applying to the Secretary, and remitting the price, 10s. 6d. Each member will only be allowed the privilege of purchasing a single ticket on these terms, which will be a personal admission, not transferable. It will be understood that all applications must be accompanied by the above-named remittance, and that tickets at the reduced rate can only be obtained from the Secretary of the Society.

Season tickets admit to the opening ceremony on Monday, 4th May.

CANTOR LECTURES.

Mr. Hungerford Pollen delivered the fourth and concluding lecture of his course on "Carving and Furniture," on Monday evening, March 30th. He described the changes that had taken place in furniture during the last two centuries, both abroad and in England, and drew special attention to the influence exerted in the revival of good taste by Sir William Chambers and the brothers Adam.

A cordial vote of thanks to the lecturer was carried unanimously on the motion of the Chairman.

The lectures will be printed in the *Journal* during the summer recess.

CORPORATE PROPERTY SECURITY BILL.

The following petition on this Bill was presented to the House of Commons on Monday, March 30, by Mr. E. Birkbeck, M.P., Member of Council, on behalf of the Council of the Society :—

To the Honourable the Commons of the United Kingdom of Great Britain and Ireland in Parliament assembled.

The Humble Petition of the Society for the Encouragement of Arts, Manufactures, and Commerce

Sheweth—

1. That the said Society has had under consideration a Bill now before your Honourable House, entituled "A Bill for better securing their property to Corporate and Quasi-Corporate Associations."

2. That the said Society was founded in the year 1754, and was incorporated by Royal Charter in the year 1847, and that it has, under the same Charter, full power to dispose of the Corpus and Income of all property, real or personal, belonging to it, subject to certain reservations and restrictions more particularly set forth in such Charter.

3. That the provisions of the Bill would unduly restrict the power and independence of the said Society in the management of its own property, and the disposal of it to the best advantage, and would unreasonably and unnecessarily augment the difficulty and expense of such management.

4. That the said Bill is calculated to encourage State interference with the private concerns of associated enterprises, and to prevent or discourage the formation and endowment of associations similar to the said Society, for professional, scientific, and social purposes, beneficial and useful in themselves, and of indirect advantage to the public at large.

Your petitioners humbly submit that the Bill is without precedent, and unnecessary, and calculated to cause mischief, difficulties, and, in some cases, injustice; and they humbly pray that the Bill may not be allowed to pass into law, or that it may be so amended by reference to a Select Committee, or otherwise, that it may not injuriously affect such Chartered Societies as the Society for the Encouragement of Arts, Manufactures, and Commerce. And your petitioners will ever pray, &c.

Sealed with the Seal of the Society for the Encouragement of Arts, Manufactures, and Commerce, this 26th day of March, One Thousand Eight Hundred and Eighty-five, in the presence of (L.S.)

F. A. Abel, Chairman of Council.

H. Trueman Wood, Secretary.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, March 17, 1885; HYDE CLARKE in the chair.

The paper read was—

THE CONGO AND THE CONFERENCE IN REFERENCE TO COMMERCIAL GEOGRAPHY.

By COMMANDER CAMERON, R.N.

I have to make a sort of apology to you to-night, because I had prepared a good deal to say on this subject on insufficient data, and this morning I received information from the President of the International Association (the parent of the Free State of the Congo), which has considerably altered my ideas of what has been done, and therefore, I have to speak from the papers I have had in my hand to-day for the first time.

I would first say a very few words as to what commercial geography is, and how it comes that this Conference on the Congo Free States which has been established at Berlin, owing to the wonderful perseverance and philanthropy of the King of the Belgians, has become what I hope will be one of the greatest factors for the regeneration of Africa. Ordinarily we have found that geographers, after exploring, come home to tell stories of adventure—of interest, no doubt, to many who stop at home—in fact, to tell a more or less entertaining story. It has been the great good fortune of Mr. Stanley, working under the King of the Belgians, to have aided in the foundation of a new State, and also, under the auspices of the Berlin Conference, to have done a great work for the future commerce of Africa. In geography, ordinarily we talk of the names and courses of rivers, the height of mountains, the habits and customs of people, and incidentally people may talk about the trade that is carried on; but this "Comité d' études du Haut Congo," which has resulted in the foundation of this Free State, was not founded only for geographical exploration, it was also set on foot to establish stations which might be of assistance to traders and to explorers, and generally to develop the commercial capabilities of Central Africa, not simply perhaps for the benefit of the merchant, but also for the benefit of the people of Africa; so that this question which we have met to discuss this evening of the new Congo Free State, and the Berlin Conference, is a subject which belongs properly to commercial geography.

I had carefully prepared a considerable amount of facts to give you, but to-day I received from Colonel Strauch, the President of the International Conference, copies of the documents recognising Congo as a Free State, and having gone carefully through the papers, I will speak to you about them. One thing which I thought at first had been a difficulty in the institution of this State was, whether the savage chiefs in the interior had, according to international law, power to transfer their sovereign rights, and also whether private individuals, not the representative of European sovereign States, or rather I should say Christian sovereign States, would have the right to contract those treaties.

Here I hold a paper signed by M. Arntz, who was a colleague of Sir Travers Twiss under the King of the Belgians, in which the question given to him to pronounce his opinion upon was—"Can the independent chiefs of savage tribes cede to any private individual the whole or a part of their States, together with the sovereign states which belong to them in conformity with the traditional customs of the country?" The question, as put, presents two aspects—first, the rights of the grantor; secondly, the rights of the grantee. First, they say, with regard to the law of nations, we must ask ourselves whether the chiefs of savage tribes can, as a rule, make treaties, conventions, and cessions of territory, or, in other words, whether the tribes they represent are considered as States capable of making international treaties. The answer given was, that from the fifteenth down to an advanced date in the nineteenth century, the rules of the law of nations were looked upon to be the special privilege of Christian races; and it was only in 1856 the Sublime Porte, by Article 7 of the Treaty of Paris of March 30th, 1856, was permitted to participate in the advantages of international law and of the European concert. Therefore his opinion is that it was obligatory on these sovereign nations that they should recognise these laws, and they could not allow those nations to participate in the advantages of the law of nations who did not recognise this law as obligatory upon themselves, and who did not practise its precepts. Publicists and moralists taught that in their relations with heathen or savage

populations, Christian sovereigns ought always to conduct themselves honestly, and observe the rules and justice of equity and of Christian morality. Then there are points raised as to how they behaved with the Indians in America, India, and other places. The conduct of the European nations towards feeble races inhabiting newly-discovered portions of the world, and not forming communities sufficiently strong to defend themselves, was often inhuman and cruel. Thanks to the progress made by humane ideas, to the better practice of Christian morality, and to the greater sway exercised by the principles of international justice in our days, feeble, half-savage races who are deprived, as yet, of the benefits of civilisation, are no longer considered merely as prey for the rapacity of civilised nations, or as furnishing a field for their enterprise. These ideas have influenced jurisconsults and publicists, have pervaded their doctrines, and have happily prevailed in practice. The science of the law of nations is not, as yet, fully formulated, and it is a science which, above all others, we cannot and ought not to formulate. But what are the conditions under which a State, as such, can exist, and be capable of negociating treaties ? According to Klüber and other authorities, a certain number of men and families congregating together, and fixing their abode in a country, associating themselves and submitting to a common chief with the purpose of ensuring the safety of all, form a State. Sovereignty is acquired by a State either at the time of its formation, or when it legitimately frees itself from a condition of dependence. Therefore, only territories without masters, that is to say, those in which no sovereign power is as yet established, can be rightfully available for occupation. In order to make occupation valid, the property must be without owners, unless you make agreement with these people who own the property, and it is not necessary for questions of people possessing a territory. According to Calvo, international treaties may be concluded even with nomadic people, having neither territory proper nor fixed abode, provided they enjoy a political organisation, and express a common will through the medium either of their chiefs or of their assemblies. In this category may be classed the Bedouins scattered in the deserts of Arabia, of Syria, of Egypt, and of Barbary in Africa, and the Turcomans who overrun the central plains of Asia. There are agglomerate populations who do not form a State, but nomads and savages have amongst themselves, and with regard to civilised people, a law of nations which rests upon the same basis as the law of nations amongst civilised races.

I thought myself, at one time, the International Association not being a representative of a sovereign State, that their acts in regard to sovereignty from the chiefs of Central Africa would not be legal acquirements until they had been confirmed by the Berlin Conference, or by the action of Europe. This pamphlet, however, says that some of the founders of the American States acquired their rights and made their treaties with the natives of America without any commission from England or from the Sovereign of England, and acquired their rights as simple individuals, but became *de facto*, from acquiring those sovereign rights from those natives, sovereign powers. Those powers were afterwards confirmed to them by the English Government, and they then came under English sovereignty. The treaty concluded by M. Savorgnan de Brazza with King Makoko, which has been recognised, first by the French Government, and afterwards by the Conference of Berlin, is one of the instances mentioned by the jurisconsults. They also mention the treaty respecting the north of Borneo, the treaty with the Sultans of Burnei and Sulu, under which portions of territory were ceded to Mr. Alfred Dent and Baron d' Overbeck. When the English Government granted a charter to the merchants holding the north of Borneo, they said they did not give any new rights, but only confirmed the rights which had previously been obtained by treaty. Then there is the instance of the foundation of Venice by fishermen in the middle ages; the Franks and others; and, according to Mr. Arntz and Sir Travers Twiss, it is proved that a private individual is capable of concluding treaties with a Sovereign, and thereby acquiring rights of sovereignty.

Under these circumstances, all the treaties which have been made by the International Association, and by Mr. Stanley, in that marvellous work which he has been carrying on for so many years in the basin of the Congo, are, according to international law, actually valid, and were valid without any confirmation from the Berlin Conference. All the treaties entered into by the different nations confirm those rights; and of the actual legal validity of the work done by Mr. Stanley in making those treaties there can be no doubt, on the authority of the great jurisconsults who have been consulted on the matter.

At the Conference at Berlin summoned by

Prince Bismarck, according to the *Acte Général*, Prussia had four representatives, Austria had one, Belgium two, Denmark one, and America two. About America, I may say that one of the two representatives was General Sanford, who was at one time Minister at Brussels. He remained in Brussels, and became a member of the International Association; he went over to America in order to get the International Association recognised by the American Government; and he was a member of the International Association at the time when he was the second American delegate at Brussels. France had one representative at the Conference, England one, Italy one, Holland one, Portugal two, Russia one, and Sweden and Norway one. The first great thing that Conference did was to establish the principle of free trade in the basin of the Congo, its embouchures and circumjacent regions; and the second was to make a declaration against the slave trade both on sea and on land. In 1816, the first great step against slavery was taken, and the second in 1826; and we have known that practically up to the present day, although we have been aided more or less, the principal work of suppressing slavery has fallen to the hands of England. When I was engaged in the suppression of the slave trade, I knew quite well that there were often quantities of slaves at a place close to the shore ready to be shipped, but I could not legally touch them. Now there is no slave trade allowed on shore, and every one of the signatories at this Berlin Conference bind themselves to suppress slavery by land as well as by sea. This was a thing which was a great deal disputed at Berlin, and a great deal is due to Sir Edward Malet, Sir P. Anderson, Mr. Mead, Mr. Crowe, and other representatives at Berlin, for the way in which they insisted that what England had been doing in the slave trade on the sea should, in this territory over which the Conference proclaimed these laws, be carried out by every nation belonging to the civilised communities of the world. The third point related to neutrality, the fourth to the navigation of the Congo, the fifth to the Niger, and the sixth was a declaration as to the occupation of territory.

The first subject was the declaration that the rights of free trade should be exercised in this basin brought under the Berlin Conference. There are to be no duties of import or export. I find from the papers I have got to-day that there are to be no transit duties; that trade is to be absolutely and entirely free to one and the other nation in this enormous territory. The only exceptions are that this is not to apply to what we have always recognised as the territories of the Sultan of Zanzibar, and of Portugal. Those are the only exceptions in this large tract of country stretching within certain limits from one coast of Africa to the other. It does not altogether go across, because there is the French colony of Gaboon as far as Sette Camma between it and the Atlantic.

[Commander Cameron then roughly indicated on a map the free trade boundary].

The only duties which will be allowed to be levied in this enormous area will have to be settled by an International Commission, which has been instituted by the Conference at Berlin, to which, as far as I know, no delegates have yet been appointed, but which the Imperial Government of Germany is to summon as soon as five nations have appointed their delegates. They are to act with respect to the questions of navigation, transit, and other difficult things, which are to be governed by rules which have been so successful in the case of the Danube Commission. Works which are for the benefit of navigation, pilotage dues, lighthouse dues, are all to be paid for, subject to the approval of this International Committee. If a man makes a railway or a canal, or whatever it is, the payment from the dues is to be calculated, so as to allow for things actually necessary for maintenance and fair profit.

The International Committee will decide as to the proper remuneration to the capitalists or the promoters who construct these works. No person will have a right, because he owns so much of this railway—because he is a shareholder or anything else—to get one bale of his merchandise carried by the railway cheaper than a man who owns nothing. The only profit that he will be able to get by being an owner of that railway will be the legitimate profit as a shareholder. But as regards the carriage of his goods, he will be exactly on the same footing as anybody else. The same thing is to happen with regard to the roads and canals. There are certain dues to be allowed to be levied which are for technical and material work. The delegates on this committee are to be paid by their own Governments, but there will be *employés* under these delegates who will be paid by certain dues which this committee will allow to be levied. I cannot speak exactly as to the dues to be levied by the Government of the State, because, unfortunately, I have not in my hands the constitution of this

new Free State; but there will be dues for the police and government of the State, only sufficient, however, to pay the actual expenses beyond the endowment which the King of the Belgians has given to it. We all know of course what the King of the Belgians has done. The whole thing really is the work of the King of the Belgians, and he has settled a sum which I have no official right to mention, but I believe it is known that he has settled £50,000 a-year on this State towards the cost of the administration. All the treaties recognising the International Association go upon the theory of the most favoured nation, but the most important of all the treaties is the English treaty, because, by agreement, in all cases of civil and criminal action the English consular authorities are to have jurisdiction over their own subjects. If any subjects or inhabitants of the Free State have any grievance against English subjects, it is to be submitted to our English consular officers; and although of course they will be punished according to the laws and constitution of the State, no British subject who comes into the State is subject to any punishment until his consular representative has found that he is actually deserving of it. Those are points which are most important. I did not know till to-day that we had obtained such a stringent protection of our subjects in the new State. I had thought that, by the constitution of this Free State, very often its judges and others might have belonged to other nations; and that there might have been some bias perhaps in certain localities against an English subject, and that perhaps this bias might be inimical to the rights and interests of English subjects.

Wares of all sorts are to be only subject to dues to pay for expenditure in the interest of trade. Of course those words "in the interest of trade" mean that there must be a proper government in the country, and therefore the International Committee will have such a very important part to play, so that when the governing body of the State is elected or appointed, they may really see what they are going to do, what judges they are going to appoint, what police force they are going to have, and whether the dues that they enforce are too heavy. The *Saturday Review* said that this International State has neither a soul to be damned nor a body to be kicked. That was taking the same idea which a good many of us had some time ago, when it was said that it would be the East India Company over again, without a Government behind it which was responsible. Perhaps it would have been better if there were one Government responsible, but we have to take the thing as we have found it. We have found that the King of the Belgians has devoted himself to the development of this State, but that he is the king of a neutral State, and is not, therefore, in a position to make Belgium the backbone of this State. We have seen already the International Commission on the Danube, and we have here an International Commission which will have the power of controlling this new State as effectively—if not more effectively—as the English Government used to control the old East India Company. From the wording of the *Acte Général*, I find that there should be no differential duties between different commodities. The duty is to be all *ad valorem*. Here I think there might be a little correction—*ad valorem* for cotton, yes; *ad valorem* for iron wire, yes; but we all know that one of the great sources of profit in Africa is the spirit trade, and I think that the spirit trade might have been excepted from that clause. I think that we might allow rum, Hamburg spirit, potato spirit, and other things of the kind, to stand rather a heavier duty than cotton, beads, or wire, which are articles innocent in themselves to the natives. There are to be no import or transit duties. This happy state is to continue for twenty years, and at the end of twenty years the Powers may again meet in conference, and say if it is to be retained. I think if the Powers who come to such a happy agreement work loyally together, and there is no undue jealousy, that we shall find that the trade in that twenty years will have developed, and that we shall see that those regulations will be retained. Another great thing is that there are to be no monopolies of traffic of ivory, or anything else. We know what a great financial success the Soudan was, before the late unhappy occurrences there, to the Egyptian Government, and that ivory was the Government monopoly; and many officers and others have made very large fortunes by paying for a license to deal in ivory. It may be argued that Egypt had a right to make these arrangements, because everything went through her territory; but this is a new State that is being formed, and therefore it cannot give monopolies, and everyone will be allowed to trade there, to come and go, to buy their ivory, and take their goods, on exactly the same terms as a subject of the Free State, a Belgian, or an Englishman. The Postal Union is to be

applied as soon as the Government, or protecting power, is able to put it into force. There is to be religious freedom, and anybody is to be allowed to build any temples, churches, or synagogues they like, and to follow any form of religion. Slavery is to be suppressed, especially the slave trade; and all religious, scientific, and philanthropic undertakings are to be assisted. The surveillance of the navigation of the Congo is to be undertaken. This term "navigation of the Congo," means all the roads and canals, and anything in the nature of public works undertaken to improve commercial communications.

All the regular trading highways are to be under an International Committee, who are to see that the Powers exercising control do so fairly and in good faith; and if two or more Powers have differences, the committee is to exercise its good offices. As regards the slave trade, the conventional basin of the Congo and the district right across to the East Coast is not to serve as a market or means of transit for slaves of any races, and all the Powers are to employ all the means at their disposal to prevent the slave trade or slavery, and to punish those engaged in it. That is a most philanthropic thing, but the question is, are we to send another expedition to Tanganyika or anywhere else to put down slavery? I do not think that we intended it should go to that point. I suppose we are not to devote all the energies of England simply to stopping slavery, because, if so, we might have expeditions all over tropical Africa. When I came down from Urua, a country which is, curiously, left in the territory of the Free State, I was travelling with 3,000 slaves belonging to a Portuguese subject, who bought them to send them to Zambesi to be sold. That was a great example of slavery, but it could scarcely be expected that any civilised Power could send a force to interfere. I suppose "to employ all the means at its disposal" means all moral means. The territories that are under this international free trade agreement are to be neutral. The signatories are to respect the neutrality of the free trade territory, including the territorial waters. The Powers occupying any waters in the free trade area have the option, in case of war, to proclaim them neutral, and to fulfil the consequent duties; and the waters which are territorial to Portugal, Zanzibar, and the Free State, on the West Coast, &c., declared neutral. If France was at war with any country, she could declare her waters neutral, and the Sultan of Zanzibar or Portugal could make their waters neutral, and they would have to fulfil all the duties of neutral States. But I think that if France were at war with England, and an English man-of-war went into French neutral waters, and a French man-of-war went after it, it would be very difficult for the Government to be as friendly to the English man-of-war as to the French man-of-war; but it is here in the Treaty.

Perhaps we are prescribing too much; still, no doubt it is better to strive for too much than for too little. The next article is that if any of the Powers that own this great territory disagree with another, they consent to submit to arbitration. The navigation is to be perfectly free, and no exclusive privilege is to be granted to companies, corporations, or private individuals; that is to become an article of international law. The navigation of the Congo is not to be subjected to anything not contained in this present Act. There should be no sliding scales and no depôt taxes. A ship putting in under stress of weather is not to be charged harbour dues or for breaking bulk, and there is to be, in fact, no payment for any ship going into these free trade waters, except for services actually rendered. The harbour dues of wharves and warehouses and the pilot dues are of course to be paid for according to the services rendered. Technical and administration expenses for general purposes, for lights, buoys and beacons, are to be calculated on the tonnage, on the Danube principles. There are to be no differential duties on tonnage, and the local tariffs are to be published at each port, and are to be subject to revision every five years. There is no mention of the order which is to make this revision of the dues, but by the text, it appears that it is to be the International Commission. As I said before, all the appliances of the Congo, the streams, canals and rivers in the Free Trade territory, are to be subject to the same rules, but the International Commission is to have no authority without the assent of the sovereign States. They cannot exercise authority, but they have a supervision, and if any of those sovereign States do wrong, they can bring the pressure of the other States to bear on them, to see that things are righted. The rights of Zanzibar and Portugal on the East Coast are re-asserted in that article. All the roads, railways, and canals are to be under the same rules, and the tolls are to be only calculated on the cost of construction

and maintenance, adding profits due to the promoters. There is constituted an International Commission under the Act. Signatory Powers, and those who may join, are to have one delegate and one vote. Any delegate representing more than one Power is only to have one vote. Delegates are to be paid by their respective Governments, but their agents and *employés* are to be paid by them out of the technical dues and others. The Commissioners, offices, and archives of this Commission are to be inviolable. The Commission is to be established as soon as five Powers have appointed their delegates. Notice is to be given to Germany, as the Conference was held at Berlin, who will see that steps are taken to summon the meeting of the Commission. The Commission is to draw up police, pilot, and quarantine rules, and these rules and the tariffs to be framed by the Commission, before coming into force, are to be submitted to the Powers. Agents of the International Commission are to check infringements of the rules. Everyone can appeal against the agents of the Commission to his consul, and if the consul finds the complaint reasonable, he is to bring it before the Commission, of whom at least three shall consider it. If the consul objects to the decision, he is to report to his Government, and they to the Powers. The Commission may ordain the necessary works for the navigation of the Congo. Where no Power exercises right, the Commission should take the necessary measures, and where there are Powers they should arrange with them. The Commission may raise and issue loans for necessary purposes on revenues raised by the Commission, but it is necessary that there should be a majority of two-thirds. The signatory Powers are to run no risk except by special agreement. Everything is to be permanently neutral, and all nations, neutral and belligerent, are to be free to trade as well in the territorial waters as on roads, canals, rivers, lakes, &c., the only exception being transport of contraband of war for belligerents. All the *employés* are to be always neutral. So far that finishes what we have to do with the work of the Berlin Conference.

Now, I wish to show you how this reflects on commercial geography. In ordinary geography we well know that there is the River Congo, we know that there is the Lake Tanganyika, and we know there are certain basins; but in commercial geography we have to study how all these rivers, all these lakes, and all possible roads and canals may be made to lead to the benefit of commerce. Commercial geography means the study of geography in such form that commerce may be benefited. If Mr. Stanley had simply come down the Congo, and said it was a great river running towards the Equator, and had never done anything towards bringing its commercial capabilities into view, that would not have been commercial geography. But the great work of the International Association was, first of all, the establishment of stations which might be a sort of ports of refuge for traders, explorers, and missionaries at different positions in Africa. Owing to the work of Mr. Stanley, this afterwards became the International Association of the Haut Congo, which now by this Conference is developed into the Congo Free State. The whole gist of the establishment of this Congo Free State has been in order to develop civilisation and commerce in Central Africa. I might say commerce and civilisation, because if legitimate commerce goes on we may be sure that civilisation will accompany it. It is by the discoveries made by Mr. Stanley and the officers of the International Association, that we have been able to see how this great area of territory may be opened. When I was at Nyangwe, nobody had gone more than a few miles west of it, and it was practically cut off from the West Coast. Now Mr. Stanley and M. Savorgnan de Brazza have found routes which, when they are properly opened up, will bring trade into the navigable portions of the Congo. When once you are on the navigable portions of the Congo, you can, from Nyangwe, go up the Congo to Stanley Falls, and on to Stanley Pool, or you can go on to Lake Moero, and to Lake Bangweolo. You can actually get into the Chambesi, and, with very few breaks, this great water system is open. The outlet of the Tanganyika is too small to be navigable, but the Lualaba and various other rivers there will all be opened to small steam boats, and it is by those that the commerce and the manufactures of Europe will be spread over an area which is one of the biggest areas to conceive as a new market. Commercial geography finds that we have got this great system, and commercial geography says, How is this water system to be utilised? How do people carry now? Everything is carried on men's shoulders. It is said that the worst use you can put a man to is to hang him; but it is almost worse to make him a beast of burden. The cost of carriage and the difficulty of carriage by man labour is

so enormous, that nothing except the most valuable commodities can possibly support it. I have seen myself fifteen or twenty tons of ivory lying idle, because there was no means of carriage; and ivory is almost the ouly thing which is brought down. One finds that for a short distance india-rubber, wax, and other comparatively valuable articles—light for their value—are brought down.

Commercial geography says, How are we to open this up, and get into the interior of this great water system? Commercial geography has worked this out, while the International Association has been looking for routes and other means by which the trade should be carried. There is no doubt, under the agreements delimiting the territory belonging to Portugal, to France, and the International Association, a cure has been found for that from the southern side of the Congo, and I believe that a railway is very shortly to be commenced. The question of these railways is one of the greatest importance possible. Wherever a railway or any means of communication can be carried into the interior of the continent of Africa, or into the dark parts of Asia, there we may be certain that not only will trade improve, which is a point of commercial geography, but we shall also find that the people will improve in civilisation; and as civilisation improves, we should educate the people up to require improvement, and to what I may call a healthy dissatisfaction with their present state. I want these people not to be satisfied with sitting in a miserable hut, and sleeping alongside a fire which they roll into; but I should like to see these people, instead of burning themselves, sleeping under Manchester blankets, and keeping themselves warm without risk of being burnt. On that line the International Association will form their railway, and this great water system of the Congo will be brought into play. We might say that that line would soon become a monopoly, although this has been so carefully guarded against; but the International Association has ceded to the French Government the Valley of the Kwilu, where they have established stations, and the French Government themselves are talking of establishing a railway up the valley. It was the first idea of the International Association that their railway should go up the Kwilu Valley. The Portuguese are also inviting tenders for a railway up to the interior, close to the River Congo. Unfortunately, the Portuguese guarantee, owing to the present state of Portuguese finance, is not sufficient to make our capitalists invest in their railway, but every one is now looking forward to the construction of this road. The great idea of commercial geography, of course, is to find out places for trade. In some places in England we hear of mills working short hours, though in other places they are working full hours. We hear that the bulk of the trade is as great as ever it was; but then we come to a very important question, that although the actual bulk of the production of manufactured goods is as great as ever it was, or greater, we do not find that the wages of the operatives increase, and we do not find that the margin of profit to the capitalist has increased. Everybody is selling as cheaply as possible, simply to keep the mills running, and therefore we have to find some place where we shall have a market for our goods which will actually pay us. It would be almost better for us if people only worked six hours and got the same wages which they get now for working ten; and it would be better for the capitalist, on selling £100,000 worth of goods, to get the same profit he now gets on selling £200,000 worth of goods. The return to the capitalist and the wage to the labouring man would be the same, and the labouring man would not be overworked as he is now.

The French government have, in the Gaboon district, nearly ruined trade by their prohibitive duties; and the differential duties in Portuguese colonies have done much harm; but I believe, from what I hear, that Portugal has an idea of revising those duties. Still, one of the great reasons why the Congo treaty with Portugal fell through was that, instead of an *ad valorem* duty of 4 per cent., which exists in Ambriz, they wanted to impose the Mozambique duty of 10 per cent. The rates and duties to be imposed in certain places is a question of commercial geography; and now, owing to the Berlin Conference, neither the 4 per cent. of Ambriz nor the 10 per cent. of Mozambique is to be imposed north of the river, just to the north of Loango.

The Niger—as to which I speak here with deference to persons present who know so much about the river—has become to a great extent an English river. We have accepted under the General Act of the Conference of Berlin certain responsibilities, but England, practically, is carrying out all the duties and all the laws communicated by the Conference, without the interference of any International Commission such

as is established on the Congo. These differences are points in commercial geography. The Niger has certain laws carried out by England, and the Congo has certain laws carried out by the International Commission. France is obtaining power on the Upper Niger, and is advancing towards Sego. If we did not know that wherever French influence comes in on the Niger she will be bound by the Act of the Berlin Conference, we should say that wherever France is we should be subject to the same rules as we have at Senegal, Goree, St. Louis, and Gaboon. We know that the Niger is subject to the General Act of the Berlin Conference, and that is a point of commercial geography. We know that if France, in any portion of the Niger basin, seeks to impose differential or prohibitory duties or to grant monopolies, she will be infringing the General Act of the Berlin Conference. The whole of this Act of the Berlin Conference is one of the greatest landmarks in commercial geography which we have.

I have now tried shortly to put before you what has come out of the action on the Congo of the Berlin Conference, and also how it bears on commercial geography. In winding up, I will just say I should think we ought all here to recognise the noble and philanthropic work of the King of the Belgians. The King of the Belgians said to me himself—"Amongst kings I am not a very great king, but amongst philanthropists and amongst geographers I may make a name for myself, and it is my wish to do so." I think if we look to the work that has been done from the East to the West of Africa, under the auspices of the King of the Belgians, and note the money which he might have spent in selfish pleasures, —his private money—which has been devoted to the cause of civilisation, commerce, and exploration, we shall admit that when the history of the nineteenth century is written, there will be scarcely one man's name which will stand higher in the account of what has been done for Africa than that of his Majesty Leopold II., King of the Belgians. I should also like to say that the King of the Belgians, in what he has done there, is most fortunate in having the cordial co-operation of everybody who has worked under him, and, above all, that he has been most fortunate in having the services of Mr. Stanley; he took Mr. Stanley by the hand, he gave him the work, he has supported him ungrudgingly, and Mr. Stanley has entirely justified this confidence.

N.B.—Many other instances might have been quoted of private individuals or associations founding states, but I only quoted a sufficient number to give point to the argument. Liberia was quoted by the lawyers, but I did not mention its name, first, because it was hardly a case in point, and secondly, because the experiment has not proved the success it should.—V. L. C.

DISCUSSION.

Mr. J. A. CROFT said he was largely connected with the trade in Africa, and more especially with that on the River Niger; but he was not quite sure of traders' positions at the present moment, as they were entirely in the hands of the Government. There was, doubtless, a very large trade, and a new field for it on the Congo, though it would take some time to cultivate before it could be thoroughly established. The trade now brought down to the mouth of the Congo was very considerable, and no doubt, when they had greater facilities of railways and steamers, the position of commerce would be much improved. One serious difficulty to be got over on the Congo was caused by the falls; but he had no doubt this problem would soon be solved, and that steamers with shallow draught, sent out in sections, and similar to what his company were building and working at present, would be running the same as they are on the Niger, having been put together by their staff of native engineers.

Mr. DELMAR MORGAN said that he was glad to hear the remarks which had been made that evening by Commander Cameron, who had been present at the Conference held at Brussels, in 1876, on African affairs, in company with Colonel Grant, the African traveller. At this Conference England was represented by three distinguished geographers—the late Sir Bartle Frere, Sir Henry Rawlinson, and Sir Rutherford Alcock. The result of that meeting was that a committee was appointed, but he was sorry to say that it was not long lived. For some reasons the advisers of her Majesty's Government did not think it right that the matter should be supported, and the funds which were collected were devoted to the late Mr. Keith Johnson's expedition to Eastern Africa. France and Germany sent out separate expeditions, and M. de Brazza annexed territory for France, so that the International Association was entirely supported by the King of the Belgians, whose energy and perseverance were untiring. Commander Cameron had quoted Professor Arntz and Sir Travers Twiss upon the legal points, but he (Mr. Morgan) might remind the meeting that, in the discussion which took place in the Congress of the United States, an instance was given of the Free State of Liberia, which had been founded on the West Coast of Africa by private assistance

almost unaided by the Government. The success of that enterprise encouraged the United States to receive the overtures made on behalf of the Association, and after a discussion which lasted several days in Congress, a vote was passed authorising the President to recognise the Association and to co-operate in its work. Declarations were then exchanged with the United States, and afterwards England, Germany, Russia, Denmark, Sweden, Norway, and Italy made treaties. With France and Portugal matters were more difficult to arrange, as questions of frontier were concerned. By the treaty made with Portugal, that country renounced her ancient claim to the mouth of the Congo, that is to say, she remained satisfied with the territory on the south bank as far as Nokki. From Nokki her frontier ran due east to the Kwango. Unfortunately, she did not renounce her claim to a very valuable enclosure north of the Congo comprising the districts on Kabinda bay as far north as Mapabé. France had obtained the lion's share of the territory; still the Association might congratulate itself upon having an outlet to the sea, though their coast line was only 37 kilometres (23 miles) from Banana Point to Yabe. Mr. Stanley, in his address to a congress at Manchester, spoke of the large trade which might be done with the Congo; but in dealing with the commercial aspect, we should not fail to recognise our great indebtedness to the natives of Africa. They were parcelling out a great territory which really belonged to the natives, and therefore, the least they could do was to give these people the advantages of superior civilisation in return for what was being taken from them.

The CHAIRMAN remarked that the object of the paper was really to call attention to the importance of commercial geography, so as to get some practical result from the valuable information which Commander Cameron had laid before them.

Lt.-Colonel BRITTEN thought there could be no doubt as to the importance of commercial geography, and, as Commander Cameron had stated, the searching and bringing to the front the interior of such a vast continent as Africa, would greatly add to the commerce of England, especially as Manchester goods would be very greatly required in that district.

The CHAIRMAN thought they had been very fortunate in having had a very temperate—he might almost say a laudatory—account of the Conference at Berlin from Commander Cameron, and likewise information from that very distinguished traveller, Mr. Morgan, as to what took place in the initiation of these proceedings at Brussels; but he thought they wanted a little more information and consideration of the matter before they could arrive at any absolute determination as to what would be the aspect of Manchester manufacturers, or English merchants, with regard to commerce on the Congo. He had listened with some amazement as to what had been said by the very distinguished jurists at Berlin, as to the law of transference of sovereignty from sovereigns or chiefs of tribes to foreign citizens, and he was glad that Mr. Delmar Morgan had partly corrected that idea. It was well known that among the States which had lately been formed by concessions from native tribes to private individuals were Liberia, Sarawak, North Borneo, and, to a great extent, New Zealand. New Zealand was colonised by private enterprise, and it was only at the last moment her Majesty's Government ran up a flag over it, there being a French frigate there ready to do the same on behalf of France. There was no doubt that sovereign rights could be conferred on a private citizen in various forms; but when he heard of provisions which Commander Cameron thought harmless, and probably very beneficial, he (Mr. Hyde Clarke) began to fear a little for English merchants. It was a very fine thing to talk of the example of the Commission on the Danube, and of having the benefit of consular jurisdiction; so likewise would all the persons who robbed and cheated them in the course of trade on the Congo; and they would have repeated on the Congo what had proved such a curse to Turkey and Egypt. The Danube Commission had not always worked quite smoothly, and anyone who knew how consular jurisdiction acted when there was more than one consul, and who knew what international tribunals meant, might fear as to the result of trading with the Congo. There was no such thing in reality as European law; there was the English system of law and procedure, and upon the Continent the Code Napoleon. The procedure would not be at all calculated to be for the benefit of English merchants. He thought it was rather a question as to what man-traps and spring-guns had been set up in the way of commerce by the arrangements which were put forward, not by Englishmen, but by men either not cognisant of the actual results of what they proposed, or who were desirous of obtaining very different results to those which English people imagined would be obtained from them. How Zanzibar, in which such large English interests were concerned, came to be dealt with in the Conference without representation, was an unexplained mystery. English persons were not called upon, in fact, to make any such concession for international advantage as was claimed from them, and anyone who knew the course of trade in Africa, knew that it was open to the Germans and to the members of other nations. But what was the history of the whole of this matter. The English had employed themselves in developing trade in these districts, and then there was the Conference at Brussels, and afterwards the King of the Belgians, and then the great ruler of Germany came forward, and made arrangements for a Congress. They were not content to participate in the labours of the English, but they actually came forward and took the management out of our hands. That was a practical illustration of what had taken place. He said this in no spirit of

unfairness or illiberality towards Germany, because the facts showed how liberal we had always been towards our German friends and kinsmen. Perhaps one of the best methods of giving an illustration of what had taken place in the Congo would be to suppose that a Conference was held at Brussels with regard to the Mississippi, for the purpose of utilising it, the King of the Belgians thinking it a very advantageous operation for the benefit of the world, this culminating in a Congress at Berlin, and an international Commission being appointed for the management of the Mississippi. That might be an extraordinary illustration, but after all it was as much like the case of the Congo as it was possible for anything to be. He thought they must wait to see what the practical illustration would be of all the arrangements which had been made at Berlin. The arrangements had evidently not been made by English merchants for the benefit of English trade, and they were not calculated to facilitate trade. They had had sufficient experience of what took place in foreign parts with some of these Powers to know the vexations inflicted on captains and merchants, and it was a matter of some importance as to how the codes were administered. They might find a ship confiscated for some infringement of port regulations, and the decision of the matter would not, after all, be, as was supposed, in the hands of English representatives, nor according to English law, but it would be in the hands of a body of men who, in most cases, would have but small sympathy with Englishmen. Mr. Delmar Morgan had been a little surprised at the result, so far as England was concerned, of the appeal made to it after the Conference at Brussels. The fact was that, though the Royal Geographical Society was represented by three most distinguished gentlemen, they were really not representatives of commercial interests or commercial authority. It was not at all surprising, therefore, that when an appeal was made to this country the merchants who had already embarked their capital in the development of the trade of the Niger, the Congo, and Zanzibar, did not go into this new undertaking. If they had known what was in store for them, perhaps they would have acted very differently to what they had done. Commander Cameron had stated what could be done at the present moment and under present circumstances; he had called attention to the study of commercial geography, though his modesty prevented him from stating what he had done in order to give a practical form to the subject. All over the world commercial geographical societies and associations had lately been formed; they had been accepted at Manchester, Birmingham, and Scotland, and according to the latest advices from Australia a strong association had been formed in Sidney, branches having been established in the other colonies of Australia. It was under these circumstances that Commander Cameron proposed the establishment in London of a British Commercial Geographical Association, and a public meeting had been held under the auspices of the late Lord Mayor, and strong support had been obtained. He trusted it would be in the power of Commander Cameron to devote himself to the work, and to finish that great object. Commander Cameron had been successful in many great objects of his life, and he (Mr. Hyde Clarke) trusted that this undertaking would add lustre to his name. In conclusion, he begged to propose a vote of thanks to Commander Cameron.

The resolution having been carried unanimously,

Commander CAMERON, in reply, said that he had spoken about the International Association as he found it, and no doubt the English Government had acted as they thought best for the interests of the country. When he proposed a scheme to Lord Beaconsfield for a charter of a company on the lines of the old East India Company to develop the trade on the East Coast, he was told that the time for charters had passed by, and therefore, he thought that in the face of the International Association, they should deal with the matter as they found it. The fact of England having only one vote at Brussels, was no doubt a great difficulty, and it was much to the credit of Sir Edward Malet that the *Acte Général* of the Berlin Conference was as favourable to England as it was. It was to be hoped that when delegates were appointed, England would name as her representative a gentleman who understood something about the question. At the first Conference, merchants were scarcely represented; it was supposed to be purely scientific and philanthropic; but now things had been entirely altered, as the merchants had come to the front. Mr. Stanley had got hold of the merchants at Manchester, and a great deal of the success of the International Association had been due to these gentlemen, though he thought there was an idea amongst some of them that he (Commander Cameron) was somewhat hostile to Mr. Stanley. There was really no ground for that idea; each had followed different routes, and so far from feeling any jealousy, he sincerely congratulated Mr. Stanley on his achievements.. He hoped the great enterprise in which Mr. Stanley had been the moving spirit would be of use to England.

HOWARD LECTURES.

ON THE CONVERSION OF HEAT INTO USEFUL WORK.

By WILLIAM ANDERSON, M.INST.C.E.

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Lecture I.—Delivered November 27, 1884.

The object of the course of lectures which the Council of the Society of Arts has done me the honour of asking me to deliver, is to lay

before you the modern views connected with the conversion of heat into useful work.

The subject is a very wide one, and, if thoroughly treated, would lead us into more branches of physical science than we have time to pursue. I must, therefore, restrict myself as much as possible to those examples of conversion of heat into work which are most useful to mankind, and with which practical life brings us into most frequent contact.

It is only within the last hundred years that the true nature of heat has been gradually explained. The experiments of Count Rumford and Sir Humphry Davy proved that heat was not a material substance, because it was capable of being developed to an unlimited extent by the application of external work, without any alteration in the weight or chemical composition of the substance from which the heat appeared to emanate. This was a great step in advance, and it was followed by one of equal importance, when Joule, Colding, Mayer, and others demonstrated experimentally that a given quantity of heat was always equivalent to a corresponding amount of work, and the almost necessary deduction which followed, namely, that heat was a consequence of the transformation of the coarse, visible motion of mechanical work into the invisible motion of the molecules of a body or the undulations of the mysterious medium, pervading all nature, through which are propagated the rays of light and radiant heat.

Gradually, likewise, it came to be perceived that there was a relationship between heat and certain other phenomena, such as light, electricity and chemical action, and we have at last been able to establish, by the irrefragable evidence of experiment, that these manifestations are forms of energy convertible, for the most part, into each other, and all having a mechanical equivalent.

As I wish to impress you with the conviction that the relationship between heat and mechanical energy is not a vague generalisation, but is a connection amenable to mathematical investigation, I must, in the first place, remind you briefly of the laws of motion, because, unless I do so, there is some danger that my arguments hereafter may not be understood.

We are indebted to Sir Isaac Newton for the first clear exposition of the laws of motion, and so complete was the conception which that great man had of these laws, that his definitions, formulated 200 years ago, cannot be improved even at this day, and some of the consequences hidden in them have only been discerned, or at any rate appreciated, in quite modern times.

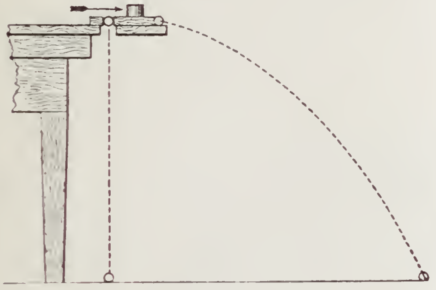
According to the first law of motion, "every body continues in a state of rest or of uniform motion in a straight line, except in so far as it may be compelled by impressed forces to change that state." You will readily grant the first portion of this law, namely, that a body will remain at rest so long as something does not make it move; but the second portion is not so obvious, because we have no experience of it on the earth. We know by observation that anything set in motion and left to itself will sooner or later come to rest, but we also know that by reducing friction and the resistance of the air motion may be greatly prolonged. A boy, starting with the same impetus, will slide farther on ice than on a polished wooden floor; a carriage with well oiled axles will run farther with the same push than when its axles are neglected; a top will spin longer in a china cup than on a gravel path, and longer still under the exhausted receiver of an air pump. Generally, we know by experience and experiment that the more completely we remove the obstacles to motion the longer will motion continue when the impetus has once been given, and it would not be unfair to argue that if the obstacles could be removed altogether, motion would never cease.

On our earth we cannot accomplish this, but in the motions of the earth itself and of other heavenly bodies we see a proof of Newton's law. They have moved for ages, and will continue so to move under the influence of an impetus once given, their paths or orbits being traced through space in submission to the other laws of motion.

The second law of motion tells us that "change of motion is proportioned to the impressed force, and takes place in the direction of the straight line in which the force acts." You are to note here that a force always produces an effect, and that by the word "motion" you must understand the "quantity of motion" or "momentum" which takes into account not only the velocity but also the mass of the body, and, further, that one motion does not interfere with any other motion the body may possess or have imparted to it. This last statement may appear paradoxical, yet you will find that it accords with every day experience. You know quite well that it is just as easy to move in one direction as in another in a railway

carriage running at express speed, or on board a swift steamer. You are not conscious that the tremendous speed with which you are moving in consequence of the earth's rotation, a speed equal to that of modern cannon shot, is interfering with your freedom of action in any way; but you may hesitate before you admit that a cannon shot fired horizontally on a level plain will strike the earth in exactly the same time as a similar shot simply dropped to the ground from the centre of the cannon. The fact is, that the ultimate result of two or more motions taking place simultaneously, is the same as if the motions took place in succession. The circumstance that the cannon shot travels at the rate of 1,500 feet per second in a horizontal direction, does not in the least interfere with the ordinary rate of falling from the height of the cannon to the ground. I have here an apparatus (Fig. 1) by means of

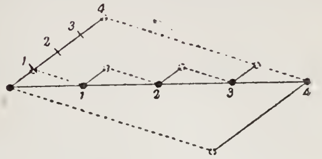
FIG I.



which I can project a marble horizontally, and at the same moment allow another to drop vertically, by striking sharply the spring slide which holds one ball, thus releasing it, and projects the other horizontally. If I have adjusted the instrument properly, you will hear but one knock when the two marbles strike the floor, they will reach it in exactly the same time, though the path of one is so much longer than that of the other. Upon this law is founded the principle of the composition of motions which are taking place in two or more directions, under the influence of as many forces acting at angles to each other.

Suppose two equal forces tend to urge a body in two directions, the velocities will be equal, because the mass moved is the same and the pressure equal. Now, by the second law, the two forces do not interfere with each other, so that, taking a very minute period of time, we may suppose the motions to take place in succession, first along one line of motion till a certain point is reached, and then from that point in the direction of the

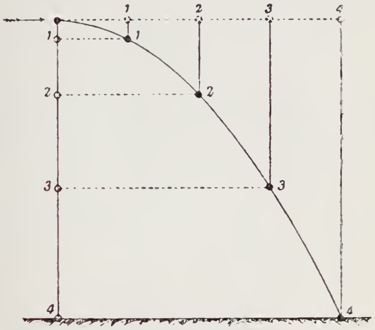
FIG. 2.



other force and for the same time. Repeating this process, it will be found that the body travels along the diagonal of a parallelogram constructed on the two lines of motion.

If the velocities are unequal, the length of the lines representing the direction of motion must be made proportional to the velocities; and if the velocities are not uniform, then the

FIG. 3.



position of the body in equal times must be ascertained for each direction of motion, and the true place of the body found by supposing the motions to take place consecutively.

The unit of measure for momentum is the unit of mass of the body, multiplied by a velocity of one foot per second. The weight of a body is a variable quantity, even on the earth, on account of the effect of centrifugal force due to the rotation of the earth, that is to say, a pound weight which will stretch a spring balance to one pound at the Equator, will stretch it over a pound at the poles. But change of motion being proportional to the impressed force, it follows that the velocity attained in a second by the action of the weight of the body on itself, in falling freely, will be proportioned to that weight; hence the weight of the body divided by the velocity per

second it produces in itself in falling freely in one second, will always be a constant quantity in any place, and is called the mass, generally denoted by the letter M.

The weight of the body is usually called W, and the velocity it attains in falling freely in vacuo at the end of one second is invariably known as g; and therefore $M = \frac{W}{g}$. g is variable like W. In England it is taken approximately as 32·2 feet per second, or roughly as 32, so that the unit of momentum is = 32·2 × 1 foot per second.

Supposing a force of 50 lbs. acts for one second on a weight of 10 lbs., what will be the velocity at the end of the second? 10 lbs., acting on itself as gravity for one second, produces a velocity of 32·2 feet per second; therefore a force of 50 lbs., acting on a weight of 10 lbs. will produce five times as much motion, or 161 feet per second.

A train weighing 200 tons attains a speed of 40 miles an hour, or $58\frac{2}{3}$ feet per second in a distance of two miles. What must have been the pull of the engine all the time to produce the result? We argue in the following manner:—If the motion was uniformly accelerated, the average speed must have been 20 miles an hour, or one mile in three minutes; hence the two miles were traversed in six minutes, and the speed attained was $58\frac{2}{3}$ feet per second in 360 seconds, therefore the speed gained was ·163 feet per second. If the train had been pulled with a force of 200 tons, it would have acquired a speed of 32·2 feet per second; but, as it only attained ·163 feet, the pull must have been so much less, or only a little over one ton.

According to the second law of motion, the circumstance that a force has produced a certain velocity in a second of time does not prevent the same force producing the same effect in addition, if it acts for another second, and hence we have the fundamental equation for motion produced by a constantly acting force $v = a\,t$; that is, the velocity v, at the end of any time t, is found by multiplying the velocity a produced in the first second by the time during which the force has acted.

The formula for connecting the space passed through with the time is not so simply arrived at. Suppose a body under the influence of a constantly acting force attains a velocity of 8 feet per second at the end of the first second, then it will have passed through a distance of 4 feet. In the second second, if the force had ceased to act, the body would, according to the first law of motion, have run over eight feet, but the force does continue to act, and to produce its full effect according to the second law of motion, and adds 4 feet more to the space passed over; hence $8 + 4 = 12$ feet will be described in the second second, which, added to the distance passed over in the first second, makes 16 feet passed over in two seconds, or the space passed through during the first second multiplied by the square of the time. At the end of the second second the velocity will be $2 \times 8 = 16$ feet; therefore, in the third second, the space passed through would be 16 feet plus the addition of 4 feet per second, or 20 feet. Adding 20 feet to the 16 feet already traversed, makes a total of 36 feet in three seconds, or 4×3^2, that is to say, the distance passed through during the first second multiplied by the square of the time; hence we have this well-known equation, for the space passed through in t seconds $S = \frac{1}{2}\,a\,t^2$, and by substitution we get

$$S = \frac{V^2}{2\,a}$$

$$v = \sqrt{2\,a\,S}$$

when a is the velocity produced at the end of the first second by the force.

By the aid of these equations, we can tell all about a body moving at a uniformly accelerated speed, if we know its final velocity, or the space passed through in a given time.

Take the case of the train, for example. What distance will the train travel to attain a speed of 40 miles an hour in 6 minutes? We have already seen that the pull of the engine communicated a velocity of ·163 feet per second, which is therefore the value of a.

The time is 360 seconds. Taking the formula $S = \frac{a\,t^2}{2}$ we have $S = \frac{\cdot 163 \times 360^2}{2}$ $= 10{,}562$ feet $= 2$ miles.

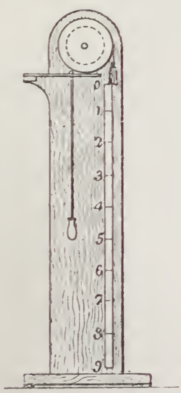
Cases of accelerating forces, that is, forces acting steadily for a time, are of common occurrence; in fact, no body can be set in motion, or have its motion changed, without the action of an accelerating force; nothing starts into motion suddenly, but always by degrees, and it is a matter of common experience that to move anything with increasing velocity requires more effort than to keep up a steady speed. The action of an accelerating force is usually illustrated by reference to gravity.

The attraction of the earth on a body near

its surface is a constant force at the same place, and the velocity produced per second, 32·2 feet, is therefore made the standard by which the value of other accelerating forces is estimated. The principles I have explained apply equally to rotatory motion.

A fly wheel resists being brought suddenly into motion, or being suddenly stopped, just as much as a body moving in a straight line. But because the parts of a revolving body are moving at various speeds, it is necessary to find a circle in which the mean motion may be supposed to take place. This circle is called the circle of gyration, and its radius the radius of gyration. In a cylindrical disc, for example, the radius of gyratin is equal to the radius of the disk divided by the $\sqrt{2}$. Having found the circle of gyration, the whole of the weight is supposed to be concentrated in it, and then the calculations are analogous to these for rectilinear motion. The circles of gyration, for bodies of regular shape, can be arrived at by calculation. In bodies of irregular shape it can be calculated when the position of the centre of gravity is known, and the rate of oscillation about any point has been ascertained. The radius of gyration (r) is the mean proportional between the length of an equivalent pendulum (l) and the distance of the centre of gravity from the point of suspension, (c), therefore, $l : r = r : c \therefore r = \sqrt{l \times c}$. I have arranged a modification of a well-known contrivance, called Attwood's machine, to demonstrate the effect of a continually acting force like gravity, or the pull of a locomotive, commonly called an accelerating force.

Fig. 4.



At the top of this tall stand is a heavy brass pulley, round which is wound a thread, one end of which is secured to it, while to the other end is attached a small weight, a little over 1 oz., so proportioned that it will fall through one foot in one second. A break, which I can release by this string, controls the motion of the pulley. On the face of the disc you see a black circle, which represents the circle of gyration. On the table stands a metronome beating seconds. I release the pulley; you see that the weight has fallen one foot during one beat of the metronome. I wind the weight up again, and let it fall through two beats; you see a space of four feet is passed through. Again, I wind up the weight, and let it fall through three beats of the metronome, and now nine feet have been traversed. I am thus able to demonstrate two things:—

Firstly, that the velocity produced on a given load by a force bears the same relation to the velocity produced in a body falling freely that the force bears to the weight of the load which it sets in motion.

The pulley weighs 1·95 lb. The circle of gyration is 4.24 inches diameter. One foot fall of the weight corresponds, therefore, to ·707 feet described by a point in the circle of gyration, and therefore the velocity acquired at the end of one second is 1·414 feet. The load set in motion by the weight is its own weight, added to that of the disc concentrated in the circle of gyration. Calling the weight x lbs., it will bear the same relation to the load 1·95 lb. + x lb. as 1·414 feet bears to 32·2 feet, the velocity acquired in one second by x falling freely by itself.

$$\frac{x}{1{\cdot}95 + x} \qquad \frac{1{\cdot}414}{32{\cdot}2}$$

$$x = {\cdot}09 \text{ lb.}$$

acting at the circle of gyration, or

$${\cdot}09 \times \frac{4{\cdot}24''}{6''} = {\cdot}064 \text{ lb., or } 1{\cdot}02 \text{ oz.}$$

acting at the periphery of the pulley.

Secondly, the apparatus demonstrates that the spaces passed through under the influence of a uniformly acting force are as the squares of the time.

When a body which is moving with a given velocity has to be stopped, the reverse action takes place; the force required to retard motion is exactly the same as that required to produce it, and, therefore, to stop a train of 200 tons weight going at the rate of 40 miles an hour within a distance of two miles would require the breaks to exert an opposing push of one ton.

It follows from these considerations that the shorter the time or space in which motion has

to be set up or stopped, the greater must be the accelerating force or pressure. In the case of one train coming into collision with another, the space is so short that that the force increases to a point which shatters the carriages.

A rifle bullet can be stopped in about eight feet without injury to itself by being fired into bran; but fired against an iron target, the space in which the motion is stopped is so small that the retarding pressure rises to a pitch which completely destroys the bullet.

Newton's third law of motion is, "To every action there is always an equal and contrary reaction." This law applies equally to statical pressures, and to momentum or quantity of motion. The reaction may consist of pressure, friction, resistance of the air, or acceleration; but whatever may be the nature of the reactions, the sum of their momenta is equal to that of the moving force.

The train we have already used to illustrate our reasoning will serve again. The power of the engine is resisted, we have seen, by a push of one ton due to acceleration. In addition to this, there is the friction of the axles and the rails, which may be taken at 10 lbs. to the ton weight of the train, or 2,000 lbs, and a variable resistance due to friction against the air, to the adverse pressure of parting it, and to the wind; all these together form the reaction to the action of the locomotive while the speed of 40 miles an hour is being gained. As soon as that has taken place, and the motion becomes uniform, the accelerating force ceases to act, and friction with resistance of the atmosphere alone remain, hence the work of the locomotive become much easier.

I have used the term "work" of the locomotive. This word requires closer examination. By the term "work" in mechanics is meant the force applied to a body multiplied by the space gone over in the direction in which the force is producing motion. The unit of work is one pound pull or pressure acting through a space of one foot, and hence called a foot-pound. The accelerating force of the train, for example, was one ton, or 2,240 lbs., acting through two miles, or 10,560 feet, hence the work done in bringing the train from a state of rest to a speed of 40 miles per hour was 10,560 ft. $\times$ 2,240 lbs. = 23,654,400 foot-pounds.

It is frequently more convenient to speak of the *rate* at which work is being done than of the total work performed. The unit of rate of work, for large quantities, has been taken as 33,000 foot-pounds per minute, and is called a horse-power. The work of getting up the speed of the train occupied six minutes; hence the rate of work was $\frac{23{,}654{,}400 \text{ foot-pounds}}{6 \text{ minutes}} =$ 3,942,400 foot-pounds per minute, or, dividing by 33,000 foot-pounds, we get 119·4 horse-power which the locomotive exerted in producing the accelerated motion of the train.

In addition to the term "work," we have another expression, "energy," which means the capacity for doing work, and it is of two kinds.

"Potential," the power of doing work latent in an advantageous position. For example, the water in a lake high up among hills has a very different value from the same water fallen to the sea level, because, in the former case, it can, by its fall, be employed to do useful work; in the latter it cannot. The chemical constituents of coal and the oxygen of the air are the same after as before combustion; they are only differently arranged with respect to each other, and yet the products of combustion are valueless; whilst in the form of coal and air they are necessaries of life, because they form a store of potential energy. The heavenly bodies moving at uniform velocities for ever are instances of potential energy; they are doing no work so long as they are moving steadily; but if the motion of any one of them were opposed by some external resistance, its velocity would be diminished in proportion to the amount of resistance offered, and work would be given out. The steam pent up in a boiler, or compressed air, are also instances of potential energy.

The other form is that of "energy of motion," or "kinetic energy." Water falling and working a water mill is an instance of this; the action of steam on the piston of a steam-engine, an animal drawing a load, &c. The sum of the potential and kinetic energies in any body is a constant quantity. Water that has fallen to the sea level has lost all the energy it may once have possessed; it has expended it in producing some kind of mechanical work. Suppose that we had an available fall of water of ten feet working a mill. Every 330 gallons falling in one minute would produce 330,000 foot-pounds of work, or one horse-power; hence the potential energy of each gallon of water is $\frac{1}{330}$ of a horse-power. But after the water has passed through a well-arranged motor, it flows sluggishly away to

the sea, having yielded up nearly all its energy, in the form of energy of motion, to the machinery it was intended to bring into activity. But suppose that, from circumstances or bad arrangement, the water flowed away at a rapid rate, say ten feet per second, this would correspond to $\frac{10^2}{64\cdot4} = 1\cdot55$ feet of vertical fall; energy due to that height, therefore, remained in the water when it left the motor, and was wasted, making a loss of $15\frac{1}{2}$ per cent.

When we know the weight and the velocity with which a body is moving, we can easily calculate its energy or power of doing work. Take the case of a 6-inch cannon shot, weighing 100 lbs., leaving the muzzle of a gun with 1,500 feet per second velocity, acquired in a barrel 15 feet long; and let us farther suppose that the motion in the gun is uniformly accelerated. Because 1500 feet velocity was acquired in a distance of 15 feet, the velocity at the end of a second would have been, had the force continued to act, $a = \frac{v^2}{2 \times 15} = \frac{1500^2}{30'} = 75{,}000'$, and the pressure to produce such a velocity would have been $\frac{100 \text{ lbs.}}{32\cdot2} = \frac{x}{75000 \text{ ft.}}$

$$\therefore x = \frac{100 \text{ lbs.} \times 75{,}000 \text{ft.}}{32\cdot2 \text{ ft.}} = 232{,}919 \text{ lbs., or}$$

nearly 104 tons. This would correspond to a mean pressure of 3·7 tons to the square inch of the powder gases, and the work done would been 104 tons $\times$ 15 feet = 1,560 foot-tons.

We can arrive at the result in a quicker manner. The shot starting from the muzzle of the gun, if directed vertically upwards, would rise to a height $\frac{v^2}{2g} = 34{,}938$ feet. If it fell from that height it would do work equivalent to its own weight of 100 lbs., which is the force impelling it multiplied by the distance fallen; or 3,493,800 foot pounds, equal to 1,560 foot tons, the same result as we obtained before, hence we have the general expression for the energy of a moving body $= \frac{W\ v^2}{2g}$ or the square of the velocity multiplied by half the mass. You mnst not confound energy with momentum or quantity of motion; the former has foot-pounds for its unit, and varies as the square of the velocity, the latter has mass mnltiplied by one foot per second as its unit, and varies as the velocity.

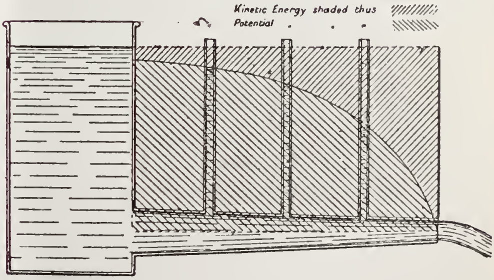
Another illustration of the convertibility of potential and kinetic energy we have in a jet of water. A fountain having a jet $\frac{3}{4}$ inch in diameter, is supplied by a reservoir 40 feet above the jet through a 3-inch pipe. According to well-known laws of hydraulics, the velocity of the water issuing from the jet will be the same as that attained by a body falling freely from the surface of the reservoir to the level of the jet, and we know that such velocity would be competent to carry each particle of water back again to a height equal to the level of the water in the reservoir. The velocity due to a height of 40 feet from the influence of gravity will be $8\sqrt{40} = 50\cdot56$ feet per second, and the kinetic energy of each pound of water issuing from the jet would be $= \frac{1 \text{ lb.} \times 50\cdot56^2}{64\cdot4} = 40$ foot-pounds. The potential energy of 1 lb of water lying 40 feet above the jet is also 40 foot-pounds, so here we have a case of complete conversion.

But the area of the 3″ supply pipe is 16 times that of the jet, hence the velocity of the water in it will be only 3·18 feet per second, and the kinetic energy of 1 lb. $= \frac{1 \text{lb} \times 3\cdot18^2}{64\cdot4} = 0\cdot15$ foot-pounds; hence in any portion of the pipe the pressure will be less than that due to the column of water by 0·15 feet, because the sum of the potential and kinetic energies must be constant. This pressure represents the accelerating force which imparts to the water the velocity with which it moves in the pipe, and is called the "head of flow."

The case of converging and diverging jets are instructive illustrations.

In a converging jet, the velocity of the water is constantly increasing, until at last, when it leaves the jet, it is evident that there is no pressure on the pipe at all, because the jet does not spread out laterally, all the potential

FIG. 5.

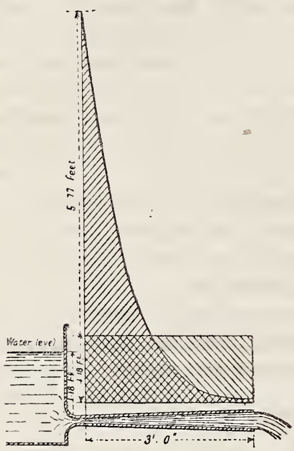


energy has become kinetic; hence, in a converging jet, the pressure on the sides of the pipe decreases continually, and the pressure

at any point may be ascertained by deducting the kinetic energy at that point of the cone from the total potential energy.

In diverging pipes, when the enlargement of diameter is sufficiently gradual to permit of the fluid always filling the pipe, which it tends to do by reason of its viscidity and

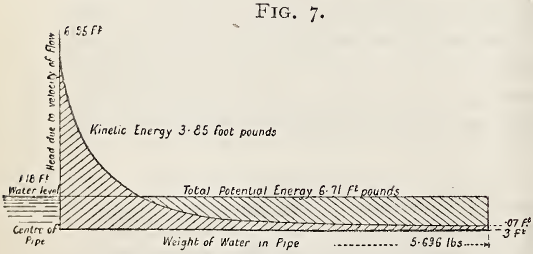
Fig. 6.



Lowell Diverging Pipe, J. B. Francis.

adhesiveness to the material the pipe is made of, the velocity with which each particle of fluid moves must continually decrease, and its kinetic energy must also decrease in proportion to the square of the decreased velocity. The energy with which the fluid was endowed,

Fig. 7.



as it issued from the narrow end of the tube, must therefore be converted partly into the potential energy represented by a tendency to push aside the atmospheric pressure against the open end of the tube, and partly to tear asunder the cohesion of the fluid, and break the stream up into slices. Both tendencies are manifested by an increased discharge from the pipe, for the atmospheric pressure, acting on the surface of the liquid above the narrow end of the pipe, augments the flow in proportion as the retardation of the fluid towards the open end cuts off the pressure of the atmosphere from that side. The whole of the conical tube is in partial vacuum from the large end backwards, the vacuum, which represents the potential energy, increasing as the narrowed part of the tube is approached, on account of the great mass of water operating to balance the atmospheric pressure, and call into play the cohesive force of the fluid.

The phenomenon may also be explained in the following manner:—Imagine the fluid in the diverging pipe to be cut up into slices, at right angles to the axis, then, because the motion is uniformly retarded, the pressure on the front of each slice must be greater than at the back. and consequently the pressure in the narrow part of the tube must be less than in the wide part. But the pressure against the widest part is that of the atmosphere, hence that in the narrow part must be less, that is, a partial vacuum.

The tendency of the fluid to break up into slices is made manifest by the pulsations which, with air, produce sound, as in a trumpet, and with liquids generate undulations which may be observed when the diverging pipe is submerged.

You will find in Mr. Francis's valuable work on the hydraulic experiments at Lowell, in the United States, a very minute account of the behaviour of a diverging pipe discharging water. He experimented with a pipe of which the sides diverged at an angle of 5° to each other, and had the orifice at the smaller end one-tenth of a foot in diameter. He found that there was no increase of discharge after the pipe had been extended to a length of 3 feet, with an outer diameter of ·32 feet, when the best results were obtained, namely, a discharge nearly two-and-a-half times greater than that due to the head. In Fig. 6 I have represented one of the experiments. The head of water over the centre of the pipe was only 1·18 feet, the velocity of discharge corresponding to which is 8·7 feet per second, but the actual velocity proved to be 21·15 feet per second, corresponding to a head of 6·95 feet. At the open end of the pipe the velocity fell to 2·13 feet per second, corresponding to a fall of ·07 feet, so that during the passage of the water through three feet of pipe the kinetic energy of each ponnd had been reduced to nearly the $\frac{1}{200}$th part. The average kinetic energy of the contents of the pipe was ·676 foot-pounds per pound of water. The total potential energy of each pound of water was

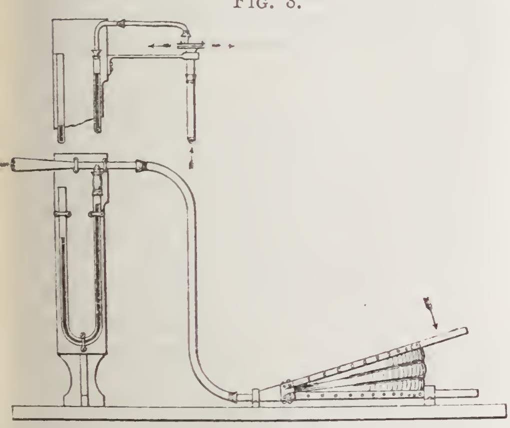
that due to the head under which the flow had taken place, namely, 1·18 feet, for that was the only motive force; hence the potential energy available for relieving the pressure on the discharge side of the orifice at the smallest part is 1·18 — ·674 = ·506 foot-pounds per pound of water.

The contents of the pipe weigh 5·7 lbs., therefore the total available potential energy was 5·7 lbs. × ·506 = 2·88 foot pounds employed in relieving the back pressure against an orifice ·1018 feet diameter, and ·00814 square feet area, hence the column of water which this would have represented was $\frac{2 \cdot 8 \text{ foot-pounds}}{62 \cdot 2\text{lbs.} \times \cdot 00814}$ = 5·69 feet. The actual extra head induced was 5·77 feet, which includes the friction in the pipe of which I have taken no account.

The ancient Romans, though they did not understand the principles on which diverging pipes acted, were well aware of the property they possessed in increasing the flow of water, and made use of them to get an undue supply from the gauge pipes of the public aqueducts.

It is immaterial what fluid we employ to produce the effects I have described. I have here a conical pipe, through which I allow a

FIG. 8.



current of air to pass. The base of the diverging mouthpiece is connected to a syphon water-gauge; you observe that as soon as I turn on the air, the column of water in the gauge rises, indicating the formation of a partial vacuum.

I substitute a plain parallel pipe for the cone, and again let the air rush through. You see that now the gauge indicates a slight pressure in the pipe instead of a vacuum; that pressure is the measure of the friction of the air against the sides of the pipe.

If a pipe be made to terminate in the centre of a flat disc, and if another disc of any light material be laid over it so, as to cover symmetrically the orifice of the pipe, then if a stream of any liquid or gas be caused to flow through the pipe, it will be found impossible to blow the covering disc off, no matter how great the pressure employed. The disc will rise a little, the fluid will issue all round, a rapid pulsation, which, if the pressure be sufficient, will declare itself in a musical sound, will take place, but it will be impossible to blow the disc off. The reason is that the fluid entering the central aperture spreads out radially, and the least rise of the disc makes the area of the annular orifice by which it escapes all round the disc greater than that of the pipe; hence the velocity of the fluid and its kinetic energy are diminished by being expended in pushing aside the atmosphere, and so keeping up a partial vacuum in the centre of the disc. But this is a state of unstable equilibrium, the disc tending always to rise higher, but in so doing reducing the velocity of the escaping fluid, and increasing the vacuum, and consequently the pressure tending to hold it down, hence pulsations, more or less rapid, arise. By connecting the centre of the disc to the syphon gauge, you see that a vacuum is at once indicated.

We must next consider the laws of impact. The consequences of impact vary according to the hardness or elasticity of the bodies striking against each other. If the bodies are elastic and do not permanently change their forms from collision, the whole of the energy of the striking body is expended in producing motion in the body struck, if the bodies are imperfectly elastic, a portion of the energy is expended in distorting or breaking up the structure of one or both bodies.

During the moment of impact of elastic bodies, that is to say in the very brief time during which the bodies are in contact, the sum of the momenta of the two bodies is the same as it was before the impact took place. In perfectly elastic bodies, the work done in resisting compression during the first period of impact is equal to that given out during the second period, when the body regains its shape and the energy so restored is divided between the two bodies, which continue to move, but with altered velocities; there is thus no conversion of kinetic energy into any other form in the impact of perfectly elastic bodies. This

is proved experimentally by the impact of two elastic balls of the same weight, such as you see suspended in this frame. The ball which strikes is brought to rest, but imparts all its energy to the ball struck, because the rebound is exactly equal to the blow.

When inelastic bodies strike each other, they do not recoil, but move on together, and the velocity of the two is found by dividing the sum of their separate momenta by the sum of their masses.

$$V = \frac{M_1 V_1 + M_2 V_2}{M_1 + M_2}.$$

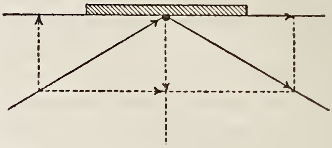
Thus a soft body weighing 10 lbs., if it strikes a body of the same weight at rest, the two will move on at half the velocity. The energy of motion in the mass of 20 lbs- will, however, be only half that of the single body at a higher velocity, because energy varies as the square of the velocity and directly as the weight, hence double the weight and half the velocity will yield only half the energy, the remaining half has been expended in distorting the two bodies. I substitute two lead balls for the iron ones hanging in the frame. I cause one of the lead balls to strike the other, you see the two now swing together, and if the surfaces are examined, a bruised and distorted place will be found on each ball. In the impact of elastic bodies, because none of the energy is absorbed in permanently changing the shape of the bodies, the sum of the energies before and after collision remains the same, that is to say, the sum of the masses of the two bodies multiplied by the squares of their respective velocities remain the same after as before the impact.

Suppose a ball weighing 10 lbs. strikes with a velocity of 20 feet per second, another ball weighing 15 lbs. moving in the same direction at the rate of 5 feet per second. The result will be that the velocity of the 10 lb. ball will drop to 2 feet per second, while the heavier ball will shoot forward at the rate of 17 feet per second, and the energy of motion both before and after collision will be the same, that is to say, 67·9 foot-pounds. When an elastic body strikes a fixed elastic substance, the body will rebound with the same velocity with which it struck.

In oblique impacts, that is to say, when the lines of motion are inclined to each other, the velocities have to be resolved in directions parallel, and at right angles to, the direction of motion of the body struck; then, according to the second law of motion, each component of the force will produce its full effect, as if no previous motion existed.

When an elastic body strikes an elastic plane surface at an angle, the direction of the blow resolves itself into motion along the

FIG. 9.



plane, and at right angles to it. According to the first law of motion, the velocity along the plane will continue uniform, while we have just seen that an elastic body striking a fixed one at right angles rebounds with the same velocity with which it struck; hence the conditions are exactly reversed with respect to the motion at right angles to the plane, but unaltered with respect to the motion along the plane, and therefore the body will glance off at the same angle as that at which it struck.

If you watch a game of billiards, you will see the laws I have laid before you illustrated in endless variety, although the conditions are unfavourable, because the balls and cushions are not perfectly elastic. The balls often have a twist, while the friction of the table and resistance of the air interferes with the uniformity of velocity.

When we speak of perfectly elastic substances, we do not mean those which, like india-rubber, have a great range of elasticity, but those like glass and hard metals, which cannot be deformed, because the elastic limit approaches very nearly that of the ultimate strength or strain-producing rupture.

I have stated that in the impact of elastic bodies no energy is expended in the deformation of the bodies, but that all is employed in producing visible motion. This is not strictly correct. When the balls in this apparatus strike, you hear a sound, that sound is caused by the vibration of the substance of the balls communicated to your ears through corresponding vibrations of the air; the energy necessary to produce these secondary motions is lost, so far as any effect it can produce on the visible motion is concerned. If the impacts were sufficiently frequent, the work expended in internal vibration of the balls would be competent to stop the motion were all other resistance abolished.

This consideration is of importance in the

theories relating to the ultimate structure of matter, and was dwelt upon at some length by Sir William Thomson in his recent address to the British Association.

I trust that I have not wearied you in thus bringing under your notice, very briefly, what I must term introductory matter. You will see, later on, the important bearing it has on the right understanding of the modern theories connected with the conversion of heat into useful work.

Miscellaneous.

PREVENTION OF FIRES IN TEXTILE FACTORIES.

It has long been an acknowledged fact that the predisposition to combustion of substances uniform in their external properties varies, to a certain extent, according to the stage of manufacture at which they may happen to be. It is on general arguments of this character that the Austrian insurance companies based their action in revising their tariff for wool-spinning establishments, and the subject has, since that time, occupied attention in other quarters. The general question of fire insurance risks in the textile industry has lately been treated by the *American Exchange and Review*, and amongst other statements, the fact is cited that in a recent period there have been more fires in cotton spinning mills than in those devoted to wool spinning, but that, on the other hand, the conflagrations in the latter case were of a more extensive and injurious character. The number of the former was less than half that of the latter, but their separate importance was greater.

Amongst various causes to which the American journal attributes the fires in question, reference is made to the sparks which, under certain conditions, are produced when machinery is driven at a high rate of speed, and which may come into contact with oiled wool, or with small particles of that substance floating in the air. The spontaneous combustion of oiled waste, and the accidents caused by open lamps, are, however, spoken of as more frequently causing conflagrations. Further, when cotton and wool are being worked together, the risk is increased, should minute particles of stone or iron exist in the mass, as the contact of the steel portions of the machinery may produce sparks.

A special danger in woollen manufacture is the use of oil. If before the cleaning process the wool is moistened with a liquid consisting of two parts of water and one part of oil, the danger of heated machinery is reduced. As, however, such a process would be prejudicial to the subsequent carding (particularly when the cleaned material lies for a certain time), it is usual to mix the wool and cotton in a dry state and clean them; oiling the mixture simply in the degree called for by its subsequent treatment. When shoddy is mixed with wool or wool and cotton, there is the further danger of spontaneous combustion arising from the insufficient purification of the rags in conjunction with the use of an unsuitable oil. Therefore, stocks of shoddy ought to be in as small quantity as possible and loose, as the premature or too compressed packing of that article is a frequent cause of accident. Rags under specified circumstances develop heat to an extent which requires their being spread out in a large ventilated space to present spontaneous combustion.

The importance of proper lubrication is commented upon as being advisable for the prevention of fire arising from undue friction. On the other hand, too much lubrication in conjunction with want of cleanliness is dangerous, as a floor saturated with oil, and machinery partially covered with fibrous *débris*, must naturally increase the fierceness of any conflagration. The danger of a fire rapidly spreading is said to be greatest in the instance of the carding rooms in cotton and mixed wool spinning establishments, while it is considerably less in wool-spinning factories. Open lights (whether fixed or portable) are most dangerous in the spinning rooms, on account of the quantity of threads, wool, dust, flock, &c., which are usually to be found there.

As to weaving factories, it is considered that less risk attaches to them, but fires are in such establishments not unfrequently caused by negligence in oiling the lower portions of the looms, and by the accumulation of warp threads or oily rags which have been used for cleaning purposes. Electric light may be considered to have obviated some of the risk connected with the lighting of weaving rooms, but it is remarked that the inherent dangers of electric illumination itself require to be more thoroughly understood than at present.

In cotton mills, the finishing department has its special risks, arising from the inflammability of the materials undergoing treatment. Regarding dyeing, it is remarked that it is not easy to define whether cotton or woollen factories present the greater elements of risk; much depending upon the heating and arrangement of the drying rooms, &c. As to dyed wool, its being perfectly cleaned is an important point. Finally, various general considerations are worthy of notice. A thoroughly well-arranged wool-spinning establishment, lighted by tar oil, would be a worse risk than a less perfectly organised cotton and mixed wool-spinning mill, illuminated by gas in enclosed lamps. The situation of a factory in the country or in a town, and the consequent absence or proximity of an organised fire-brigade, as well as the arrangements for diminishing the risk from certain dangerous processes, are circumstances exercising a special influence upon each particular case. As to the size of factories, it has been found by experience that the

largest establishments are usually the best arranged and most amply provided with fire-extinguishing appliances, while the machinery and general organisation are usually on approved systems.

In the foregoing remarks there is a brief summary of the statements of the American journal which have met with detailed comment in the *Allgemeine Zeitschrift für Textil Industrie*, one of the leading German authorities on textile subjects. The accumulation of particles of wool in the machinery used for tearing mungo is easily prevented by a simple mechanical contrivance, and it is considered that some of the fears expressed by the American journal are exaggerated. It is admitted that the risks of fire in spinning mills are greater than in cloth factories, but the reasons for this circumstance are considered to be different from those brought forward in the preceding remarks. It is remarked that the circumstances attending the supposed dangers in carding find a parallel in other mechanical operations of a harmless character. It is quoted from practical experience that the proper oiling of rags, wool, &c., efficaciously prevents spontaneous combustion, and it is asserted that the same may be said of the spinning waste resulting therefrom, if it is not at once firmly packed in large bags, which would be a punishable negligence. Mungoes (from good cloth rags) which are oiled in the proper manner, rapidly cool, although in the process of tearing they become heated, and this cooling process, it is asserted, goes on while they are packed in bales. The same remark is applied to shoddies, although the risk of spontaneous combustion is much less.

The all-important point is considered to be the purity of the oil used, for no precautionary measures are of use if the wool has been treated with adulterated oil, the material becoming and remaining heated. The only means of preventing the spontaneous combustion of the waste which results are to wash it immediately or bury it. Hence the suggestion is made that insurance policies should contain provisions stipulating the employment of pure olive oil, or oleine free from acid and properly saponified, for the oiling of wool, rags, &c. It is remarked that the slight difference in cost is made up by various contingent manufacturing advantages. It was also proposed that cleaning rags, &c., should be collected upon an organised system, and the argument is forcibly urged that fire-risks would in this way be considerably reduced, and that an eventual reduction of premiums would be quite compatible with increased dividends.

In conclusion, the German journal points out the relative frequency of conflagration in spinning mills as compared with other textile factories, and does not hesitate to attribute such occurrences to the spontaneous combustion of oiled wool, &c., and of the waste which results, as well as of oil cleaning rags, &c. The use of pure oil would, it is considered, obviate these evils, the existence of which is generally acknowledged.

PRODUCTION OF INDIA-RUBBER IN BRAZIL.

Consul Andrews, of Rio de Janeiro, says that the rubber industry is the principal resource of the two great provinces of the Amazon Valley, Pará and Amazon, and its product occupies the third place in the list of the national exports. The rubber tree requires a growth of twenty to twenty-five years before it begins to produce, and for this reason little or nothing has been done for its propagation. The milky sap which forms the rubber is taken from the wild tree, which is to be found throughout the forests of the Amazon, and many of its affluents. The industry being principally in the hands of an uneducated and half-civilised nomad population of Indian mixture, is of a crude character, and is pursued mostly on the national domain. Nothing of late years has been done to improve the system of labour, and a wasteful and exhaustive system has been followed for half a century, with the result that millions of india-rubber trees have been destroyed, and many others abandoned from premature and excessive use. There are instances of groves of trees which, by careful use, and by not permitting them to be tapped in the months of August and September, in which they change their leaves, have been yielding for thirty years, and are still in good producing condition. The tree thrives only on soil which is annually submerged to a depth of three or four feet, and prefers the lowest and most recent river deposit. The rubber gatherers are temporary squatters, and their usual dwelling is a hut with low roof of palms, beneath one end of which there is a raised floor, or framework of lath, one or two yards from the ground, to which the occupants retreat at high water. The following is the system employed in collecting the india-rubber. Narrow paths leads from the gatherer's hut through dense underwood to each separate tree, and when the dry season sets in small holes are cut with a hatchet in the bark of the trees. The milk-white sap immediately begins to exude into pieces of bamboo, tied below into little clay cups, set under the gashes to prevent its trickling down the stem. The gatherer goes from tree to tree, and on his return visit he pours the contents of the bamboos into a large earthern vessel, provided with straps, which he empties at home into a large turtle shell. He then commences to coagulate it with the smoke of palm nuts, and pours a little of the milk evenly on a light wooden shovel, which he thrusts into the thick smoke issuing from a little narrow chimney made by the neck of an earthern bottle. He moves the shovel several times to and fro with great rapidity, when the milk is seen to consolidate and to take a greyish-yellow tinge. He then puts layer on layer, until at last the rubber on both sides has reached a thickness of two or three centimetres; it is then cut on one side, taken off the shovel, and hung in the sun to dry. A good workman can prepare five or six pounds of solid rubber in an hour. From its initial colour of clear silver grey it turns to a yellow, and finally be-

comes the well-known dark brown of the rubber, such as it is exported. The more uniform, the denser and freer of bubbles the whole mass is found to be, the higher the price it realises. Almost double the value is obtained for the first-rate article over that of the most inferior quality, which is nothing but the drops collected at the foot of the trees. The export of india-rubber has increased rapidly in the past few years. From Pará and Manaos, the two principal ports in the Amazon Valley, the export during the five years from 1839-1844 was 2,520,000 pounds, of the value of £79,000. In the five years, 1854-1859, it had increased to 21,500,000 pounds, of the value of £800,000; and in the five years, 1874-1879, to 66,000,000 pounds, of the value of £4,400,000. In 1882, the quantity exported was about 22,400,000 pounds, with a value of £3,000,00. A very heavy export duty is collected on this article, the imperial duty being 9 per cent. on the value, and in addition a tax of 12 per cent. is collected by the province of Amazon, and 13 per cent. by the province of Pará, making 22 per cent. on all that is exported from the latter province, and 21 per cent. on exports from the former.

Correspondence.

MUSICAL SCALES.

After the reading of Mr. Ellis's classical and highly interesting paper, I should, had there been time for any discussion at all, have risen to make the few observations with which I now trouble you, as even my humble testimony in confirmation of one point mentioned by the reader of the paper may not, perhaps, be entirely out of place.

Mr. Ellis spoke of, and illustrated, with his accustomed lucidity, the "pentatonic scale" in vogue amongst the Javanese—or Javese, as he prefers to call them—and, in the printed text of his paper now before me, he endeavours with some trouble and much ingenuity, to explain his notion of the probable constituents and genesis of that scale. Some years ago, I was accidentally thrown into the company of a very intelligent young Javese, who possessed a rather soft, by no means unmusical voice, and who was able, with some degree of effort, to sing several notes of our ordinary "heptatonic scale" immediately after they were sounded upon the piano. Except when following them one by one, however, he never succeeded in singing all the notes of the gamut correctly, although, when left to himself, he at all times gave the correct musical enunciation of the pentatonic scale which, and no other, seemed "to come natural" to him. If a guitar, or a banjo with six strings, were handed to him, and a suitable note sounded, he would readily tune the strings by ear in accordance with the scale just referred to. A Burmese gentleman I met a few times, also exhibited the same faculty, but in a less marked degree. Both could give the intermediate notes with tolerable accuracy.

To my thinking, however, although almost every musical scale is, without doubt, more or less artificial, the pentatonic scale of equal temperament is, in all probability, the natural—or at least the most natural—one, inasmuch as I have found evidences of its existing, as it were, normally, not only amongst comparatively uncultivated races, but also in the sounds emitted by various animals. Thus, a Scotch terrier I formerly had, was wont to express his pleasure at my return home by a not unmusical whine, which could not be faithfully imitated by any instrument as ordinarily tuned, except, perhaps, as a rough approximation, upon the "black notes" of the piano or harmonium. But any instrument with the octave "pentatonically" divided, enabled one to give the *motif* of the "dog's tune" unmistakeably. From several observations made upon the "purring" of cats,* I am led to believe that it rises from the lower fundamental note by almost inappreciable fractions to an interval of a whole "pentatonic" tone, or occasionally even as much as two entire notes, according to the amount of feline enthusiasm intended. The cuckoo's well-known performance starts just three octaves above that of the cat, but descends instead of rising. The "call" of this bird is very generally written as if it were composed of the notes "sol-mi" of the common scale; if, however, it be attentively studied, it will be found an integral part of a pentatonic, not heptatonic, scale. I am speaking, however, of mature, fully developed cuckoos; the young birds, like other juveniles, do all kinds of wild things before they have "learnt their notes." The robin, too, is of pentatonic proclivities; but I might multiply instances until your space and patience were alike exhausted.

In conclusion, I will merely say that I have met with two instances of what might be called pentatonic idiosyncrasy in the human subject, even in polite English circles, where there were no surroundings calculated to induce any reversion to what was probably the natural or "normal" musical scale. One of these—a young lady—never succeeded in singing any moderately difficult song of the usual kind, correctly throughout; accident revealed (what I considered to be) the cause, and having arranged some music, and the instrument also, upon strict "Javese" or "pentatonic" principles, I found that she then always rendered the former accurately, and without any apparent effort.

CLAUDE TREVELYAN.

London, March 26, 1885.

* Persian cats alone are meant here.

General Notes.

Indian Linseed Crop.—According to the Director of Agriculture for the Central Provinces of India, "The district reports are, on the whole, very favourable. Linseed is sown three weeks earlier than wheat, and did not, therefore, suffer to the same extent as wheat from the early cessation of the monsoon rains. There is a steady annual increase in the area under linseed, owing to the active demand for it. The export of linseed is, next to that of wheat, the most important feature in the export traffic of these provinces, and cultivation is steadily responding to the demand of the Bombay market. The increase in linseed cultivation is especially marked in districts such as Nagpur, in which much of the soil is not of sufficient depth for the produce of wheat, and where the growth of linseed is increasing at the expense of the cotton and the millet crops. It does not seem extravagant to assume an increase of at least 10 per cent. in the linseed area of the current year. The prospects of the standing crop are satisfactory; rain was much wanted for it lately, and in some places the plants were beginning to wither. But rain has now very generally fallen and the crop has immensely benefited. A little harm has resulted in the Raipur district from the 10 days of cloudy weather at the end of December, which have been prejudicial to the proper fertilisation of the flowers, but after making allowance for this a full crop may be expected in Raipur as well as in Bilaspur, and the reports from other districts show that prospects are very nearly, if not quite, up to the average throughout the provinces."

Utilisation of Waste Wood.—In the course of a lecture on forestry, recently delivered at Coniston, Mr. J. Robinson remarked that the Exhibition of Forestry, in Edinburgh, last year, brought to light an industry which was hardly known in England, except by its results, and that was the manufacture of paper pulp from the thinnings, &c., of trees. No less than fourteen of such manufactures were grouped side by side at that Exhibition, and yet so little does one part of the world know about the doings of the other part of it, that each of those pulp makers had, till then, apparently cherished the notion, that paper pulp making from wood was an industry that was peculiarly his own, and some of those Continental pulp makers sent to England from sixty to eighty tons of pulp weekly, to be used in the printing of daily and other papers. Here was an industry hitherto confined to the Continent, and yet, why need those foreign manufacturers be allowed thus to monopolise an industry for which we had such abundant facilities at home? The thinnings of Scotch firs and spruces, six inches in diameter, were the wood most suitable for being reduced to pulp of this kind; at present much of this wood was used only for the fire, or allowed to rot, as perfectly useless, and yet with enterprise and capital, it might be rendered quite as valuable as the paper pulp imported from abroad. Again, there was much wood required as prop wood for mines, and this could be supplied by the thinnings of the Scotch fir, which, in five years, required thinning again. Then there was match making. Matches were a most important and essential item of our trade; and yet, notwithstanding all our facilities for growing the alder tree, and other wood suitable for the manufacture of matches, we imported from Sweden and other northern countries most of the matches we use.

Iron in New South Wales.—Almost every description of iron ore is found in the colony, including brown hæmatite, very large and extensive irregular deposits and pockets of which occur at Wallerawang, Blackheath, Newbridge, Lithgow Valley, Jamberoo, Nattai, Berrima, Mount Keira, Mittagong, Broughton Vale, Port Hacking, near Gundagai, Mount Tellulla, and Newbridge or Back Creek, near Blayney. Deposits of this ore are being worked and smelted at Lithgow; near Cooyal; eight miles from Jervis Bay; Burra Burra; Narrandera; fifty miles west of Forbes, Lachlan River; Narellan Creek; Scone; near West Maitland; in the Coal Ranges, Clarence River; at Tamworth; between the Lachlan and Bogan rivers; and in many other places, such as between Mount Tomah and Mount King George. In fact, this mineral is one of the most widely diffused in the colony. Between Cooyal and Warigal Springs a wide vein of brown hæmatite is reported with magnetite. Pseudomorphous crystals of iron pyrites changed into brown hæmatite occur at Carwell. Brown hæmatite is common on the Bingera diamond fields, in the form of small concretionary nodules, some of which are as spherical as marbles; in other cases they are more or less elongated; or two or three of the globular forms may be joined together. Some possess a curiously wrinkled or corrugated surface, but most are quite smooth, but not polished, the material being rather soft. On breaking them open, they are seen to have traces of a concentric structure; the outer portions occasionally present indications of a radiate fibrous structure also. Stalactites of hæmatite are often formed by the ferruginous springs found over the coal measures, as at Berrima and Nattai, county Camden, and elsewhere, and the deposits of brown iron from these often contain beautiful impressions of leaves and other objects; also in botryoidal and other mammillated forms, with a well-marked concentric structure.

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FRIDAY, APRIL 10, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

INTERNATIONAL INVENTIONS EXHIBITION SEASON TICKETS.

The Executive Council of the International Inventions Exhibition have consented to allow Members of the Society of Arts the privilege of purchasing Season Tickets for the Exhibition at half-price (10s. 6d.) Any member desiring to avail himself of the privilege can obtain a ticket by applying to the Secretary, and remitting the price, 10s. 6d. Each member will only be allowed the privilege of purchasing a single ticket on these terms, which will be a personal admission, not transferable. It will be understood that all applications must be accompanied by the above-named remittance, and that tickets at the reduced rate can only be obtained from the Secretary of the Society.

Season tickets admit to the opening ceremony on Monday, 4th May.

PRACTICAL EXAMINATION IN VOCAL AND INSTRUMENTAL MUSIC.

The next Examination in London will be held by Mr. W. A Barrett, Mus.Bac. (Oxon.), at the House of the Society of Arts, 18, John-street, Adelphi, W.C., during the week commencing 8th June, 1885.

Full particulars can be obtained on application to the Secretary.

Proceedings of the Society.

HOWARD LECTURES.

ON THE CONVERSION OF HEAT INTO USEFUL WORK.

By William Anderson, M.Inst.C.E.

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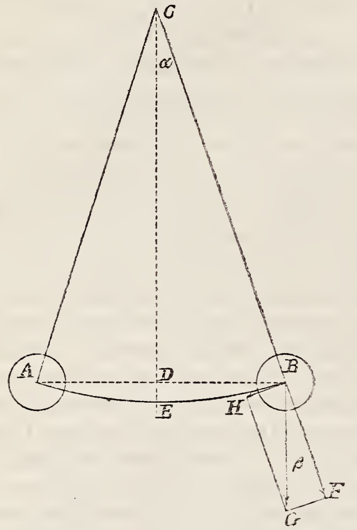
Lecture II.—Delivered December 5th, 1884.

In my first lecture, I dwelt briefly upon the laws of motion, the principles of work and energy, and the laws of impact. This evening we have to consider several other phenomena, the right understanding of which is necessary before a correct idea of the conversion of heat into useful work can be formed. The theories of oscillation and vibration, involving, as they do, sufficiently high mathematics, might alone occupy the whole of the time I have at my disposal. I must, therefore, deal very briefly with them, although they are so intimately involved in the immediate scope of these lectures. Oscillation or vibration, then, is motion propagated through the substance of a body by short excursions of the molecules of the body to and fro, either in direct lines or in closed curves. A familiar illustration of an oscillating motion is a pendulum; and it is also an instance of the mutual relations between kinetic and potential energies. The moving force is gravity. The bob of the pendulum falls from the highest point to which it has been raised to the lowest point, and in so doing, the whole of the potential energy with which it had been endowed, just when allowed to drop, is converted gradually into kinetic energy, and this notwithstanding that its path is not free, but constrained by the rod of the pendulum; but this constraint, according to the second law of motion, does not interfere with the action of gravity. The kinetic energy with which the bob is endowed at its lowest point is competent to carry it again up to the same height as that from which it fell, and in doing so, the energy is gradually changed till again it all becomes potential. Were it not for the friction of the attachment of the pendulum-rod, and the resistance of the air, the oscillation, once set going, would continue for ever, and at a uniform speed, because the force causing it is constant. In clocks, where advantage is taken of this property of a pendulum, the retarding

forces are counteracted by the escapement, a mechanical contrivance set in motion by a wound-up weight or spring, which gives the pendulum a little push during each oscillation.

FIG. 10.



Let A C, B C, (Fig 10), be the two extreme positions of a pendulum. The force acting on the bob is its weight represented in magnitude and direction by the vertical line, B G. This force is resolved in the direction of the rod, B F, and at right angles to it, and therefore tangentially to the arc described, B H. Now, because B G is parallel to C E, and H G to C B, therefore the angle β is equal to the angle α. H B, which represents the magnitude and direction of the impelling force throughout the swing, is proportional to the sine of β, and therefore to the sine of α, and consequently to D B. Now if any elastic rod fixed at one end be pulled to one side, the resistance to deflection for moderate distances will be proportional to the amount of deflection or to the length D B, and therefore such a rod, if let go, will vibrate with the same speed as a pendulum; and the general equation for the maximum velocity attained applies to all vibrating bodies, namely—

$$v = \frac{\text{D B} \times 2\pi}{\text{T}}$$

Where T is the time of a complete vibration, and D B is half the amplitude of the swing.

Let us take the case of a pendulum beating seconds, its length L in feet will be—

$$\text{L} = \left(\frac{\cdot 5 \text{ seconds}}{\cdot 554}\right)^2 = \cdot 8145 \text{ feet.}$$

The maximum velocity will be—

$$v \text{ ft.} = \frac{\cdot 25 \text{ ft.} \times 2 \times 3{\cdot}1416}{1 \text{ sec.}} = 1{\cdot}5708 \text{ feet per second.}$$

The versed sine D E is the height which the bob falls each half excursion.

$$h = \cdot 8145 \text{ ft.} - \sqrt{\cdot 8145^2 - \cdot 25^2} = \cdot 0393 \text{ feet}$$

Now, if our reasoning has been correct, we shall find that the potential energy of the bob equals its kinetic. Suppose the bob to weigh 1 lb. the potential energy, in the positions A or B = ·0393 ft. × 1 lb. = ·0393 foot-pounds The kinetic energy in the position E where the velocity is a maximum, and = 1·5708 ft. per second.

$$\text{Kinetic energy} = \frac{1{\cdot}5708^2 \times 1 \text{ lb.}}{64{\cdot}4} = \cdot 0383$$

The two results are practically identical.

In watches, the pendulum is replaced by a wheel attached to one end of a spiral spring, the other end of the spring being fastened to the framing which supports the mechanism. When the wheel is turned a short distance, the spring is either wound up or unwound, and by that means brought into a state of tension, and then, being set free, the spring restores the wheel to its original position, and in doing so converts the potential energy imparted by the forcible compression or extension of the spring into kinetic energy, and this expends itself in carrying the wheel as much past the neutral point as it had been moved in the opposite direction at starting. This oscillating motion would also continue for ever, were it not for the imperfect elasticity of the spring, the resistance of the air, and the friction of the journals; and, as in the case of the clock, these resistances have to be overcome by an escapement actuated by a wound-up spring, which gives the wheel a little push at each oscillation.

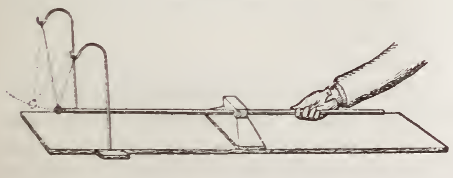
Vibrations may be propagated in many ways. Any elastic material may be set into longitudinal vibration. A wire stretched between two fixed points, if rubbed longitudinally, will be set into vibration. The action is of this nature. A portion of the wire rubbed is stretched a little more than the rest by the pull of friction; when the elasticity of the wire overcomes this pull, a portion of wire springs back, and, being elastic, returns beyond the neutral position as far as it was

dragged from it. The motion is analogous to what we can see in the pendulum and balance; the elasticity of the material is the moving force. In obedience to the third law of motion, no part of a continuous bar can spring backwards and forwards without the neighbouring sections participating in the movement, and so the oscillation travels along the bar according to well established laws; and because the wave of oscillation causes alternate compression and extension in the bar, it must also cause corresponding changes in its cross section—the bar will be reduced in diameter where extended, and increased where compressed. It is probably to this change of diameter, slight though it be, that we are indebted to the beneficial results of "jarring," anything which fits very tight into a hole when we want to get it out. The sudden alternation from compression to tension in highly elastic and brittle bodies, such as glass, is so intense that they may be fractured into thin slices through being brought into longitudinal vibration by vigorous rubbing.

The mode by which longitudinal vibrations are established and propagated may be very distinctly seen by fastening to some support one end of about a yard of india-rubber pipe, and holding it out horizontally, but without stretching it much, with the hand; then, if the end near the hand is well wetted, and the fingers of the other hand rubbed lightly over it, the pulsations will be distinctly felt as they are formed by the alternate catching and releasing of the pipe by the fingers. The vibrations will be propagated along the pipe to the opposite end, and will become apparent as transverse vibrations which result from the sudden alterations of length, due to the pulsations jerking the pipe up and down.

I have here a brass tube fastened securely

FIG. 11.

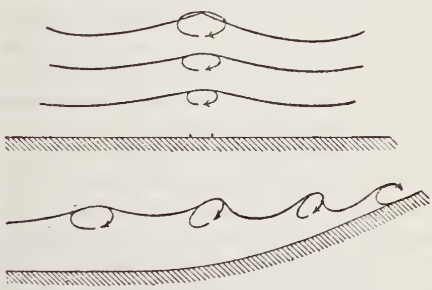


by its middle to a stout board. Opposite one end is hung a small glass ball; I rub my gloved hand, powdered with a little rosin, along the rod, you hear a musical note, and at the same time the ball is repelled with violence from the end of the rod. The note is between F sharp and G, corresponding to about 1,400 pulsations per second; therefore, although the excursion of each portion of the rod is but small, the velocity is very great, and hence the sharpness of the blow delivered to the ball.

All solid substances may be brought into transverse vibrations. Familiar illustrations of this are tuning forks, the sounding boards of musical instruments, and stretched strings. When these motions are sufficiently pronounced, they can be seen by the naked eye, but when very rapid and of small amplitude, they can be made to register themselves, so as to become visible, by mechanical means.

Waves are propagated through fluids and gases, such as water and air, much in the same way as along a rigid bar, that is to say, by alternate compression and extension, but the lines of compression and rarefaction extend all round the point from which the impulse is given, spheres of compression being surrounded by spheres of rarefaction, and consequently the impulse travels outwards in every direction, and as the energy of motion is imparted to constantly increasing masses, so the velocity of motion is decreased, and the waves become more and more feeble as they recede from the point whence they started. Waves on the surface of a liquid are produced by a similar oscillation of the particles of the liquid, that is to say, each particle describes a curve of elliptical form, the plane being in the direction of motion of the waves, the long axis in deep liquid horizontal. The moving force is

FIG. 12.



usually one acting on the surface, generally the action of the wind; the disturbance is propagated deeper and deeper, the energy of motion acquired at the surface is communicated to greater masses, and hence the motion becomes more feeble, the elliptic paths of the particles become flatter, and at last vanish altogether. In moderate depths, when the

bottom is reached, there remains a simple to and fro movement. As water, for example, shoals towards the shore, the lower part of the orbits of the particles is retarded, hence the long axes of the ellipses become sloping, they approach more and more to the vertical, and at last the continuity of the ellipses is destroyed, and the wave breaks in a crest of foam on the beach. The action of the wind in creating waves is analogous to that of friction in producing pulsation in a solid rod, the friction of the air against the water which it slips over, tends to move the particles along and heap them up; this heaping goes on till the weight is more than the friction of the air can support, the mass of water falls, and, like the pendulum, falls as much below the mean level as it was raised above it. The elliptic motion is due to a combination of the vertical motion produced by gravity, and the horizontal motion due to the wind.

Wave motion, like all other oscillating movements, once started would go on for ever, were it not that the resistance of the air and friction of the particles of water among themselves tend gradually to bring the motion to rest. The movements which I have described may be plainly seen from any pier in the deep water. Looking down on the waves, and observing some floating object, it will be seen to move a little backwards and forwards as well as up and down, while in shoal water the weeds growing on the bottom are seen to wave to and fro only.

If you watch the surface of the sea, you will notice an infinite series of waves existing at the same time, and being propagated in various directions. This is in accordance with the second law of motion, and you would expect consequently that if the motion of two waves happen to be in the same direction that the motion of the water would be augmented, and, on the contrary, if the motion happened to be in opposite directions it would be reduced, while, in the intermediate stages, there would be a resultant motion depending upon the magnitude and direction of the other two. This effect is known by the name of "interference" of waves, and may best be studied on the surface of calm water, in which waves may be generated at pleasure. In a calm sea the long smooth rollers, intersected in various ways by minor waves, may also be watched with much profit. It is not alone in water that this interference takes place, but in all cases of vibration, whether in solids, liquids, or gases, the main vibrations are accompanied by minor ones. In musical instruments these minor vibrations are called harmonics or overtones, and to them is due the quality, tint, or *timbre* of the note. The difference in richness of the pure fundamental note and the one accompanied by its overtones, is much like the difference between the sea on a very calm day and the sea when a breeze is sweeping over it. In the former case you see only the long, sleepy, oily looking swell of previous disturbance, in the latter the same swell decorated and rendered brilliant by innumerable systems of wavelets superimposed on the majestic rollers of the swell and on each other. In the same way interference of pulses in the air are recognised by the dullest ear as "beats," that is to say, periods of comparative silence caused by the neutralising coincidences of regions of compression and rarefaction in the sound wave.

As a consequence of the second law of motion, all wave motions are capable of being augmented by fresh impulses communicated synchronously, that is, timed so as to be always in the direction in which the particles are moving, or of being diminished and neutralised by the opposite course. The energy latent in wave motions is small compared to the apparent result produced. Thus, on the sea the friction on the surface of the water of a brisk breeze, having a velocity of 30 feet per second, is but $\frac{1}{10}$th of an ounce per square foot, yet the constant and synchronous application of this slight force is capable of raising considerable waves. The power necessary to produce the volume of sound which emanates from a large organ is not more than that which one man working the bellows can easily supply, and yet the flood of sound fills a spacious building, and is even competent to affect it with a perceptible tremor. The lightest touch of a wetted finger on the edge of a tumbler will set it vibrating with exceeding rapidity, emitting a shrill note, while the slight pressure of a feather will instantly damp the vibrations of a piano string.

The last kind of vibration that I have to bring under your notice is that of a mysterious substance which, for want of a better name, we call ether, which pervades all space and all bodies, whether solid, liquid, or aeriform. It is this ether which links us to the planetary world, for it is the medium by which light and heat are communicated to the earth from the sun and the other heavenly bodies. It must be of extreme tenuity, because it offers no appreciable resistance to the motion of the planets, and, as I have just said, permeates all

substances. You may, at first, be disposed to hesitate at accepting a statement that solids can thus be permeated, but we have reason to believe that, looked at with the mind's eye, the densest solid is no better than a very porous piece of sponge. The evidence of the truth of what I have stated lies in the remarkable phenomena of the occlusion of gases in solids and liquids, that is to say, the power which solids and liquids possess of absorbing many times their own bulk of certain gases. Thus platinum, the densest of all substances, occludes as much as five times its own volume of hydrogen without change of bulk; the metal palladium as much as 643 times its own volume of carbonic oxide. It is, in fact, upon this property that the manufacture of steel from wrought iron by the cementation process depends. In that process bars of wrought iron are packed with substances rich in carbons into iron boxes, and closely cemented in them; they are then exposed to a red heat for many days, during which carbon slowly penetrates right into the heart of the bars. Again, platinum and iron are, at a red heat, permeated by gases to a remarkable extent, that is to say, gases pass right through them. Liquids, again, absorb many gases readily. Rain water takes up $2\frac{1}{2}$ per cent. of its bulk of atmospheric air, and the principle on which the manufacture of aërated drinks depends is that water can, by pressure, be made to hold many times its bulk of carbonic acid gas. At the atmospheric pressure water dissolves about its own volume of the gas, but as the pressure rises, and the gas is reduced in bulk, more gas is absorbed, and it is found that the weight of gas taken up is nearly in direct proportion to the pressure, a relation which the theory of the porosity of bodies would lead us to expect.

Our knowledge of molecular physics is still very limited; the subject is now occupying the attention of some of the most powerful minds of the age; it comes within the province of the chemist, the mathematician, and the physicist, and any theories put forth must satisfy the claims of each. Speaking broadly, I may say that the elementary substances are composed of atoms or particles incapable of further subdivision, and these atoms have each a definite weight, and probably a common specific heat, that is to say each atom requires the same quantity of heat to raise its temperature one degree. Compound bodies are composed of molecules which are formed each of a definite number and arrangement of the atoms of the elements of which they are composed. Of the structure of the atoms and molecules little or nothing is known, though many bold and ingenious conjectures have been made, but long years will probably elapse before any fully satisfactory theory can be established. The atoms of simple substances, and the molecules of compound bodies, are not in permanent contact with each other. In solids they are in a state of oscillation due to their temperature; this oscillation is analogous to that of a pendulum or watch balance, the forces acting on the particles being mutual attraction, and that force which causes the movement which we call heat. Molecular motion, like any other, may be communicated from one body to another, or propagated along the same body, as you saw in the experiment with the brass tube. A body in which the particles are oscillating more vigorously than in another body, if placed in contact with it, will gradually impart a portion of the motion of its own particles to those of the body it touches, and in consequence the motion of its own particles will be enfeebled, because the total kinetic energy of the two substances remains constant.

I have here a light framework from which are hung a number of heavy balls by strings of equal length. I set one ball swinging across the frame, the pull upon its string, due to the motion, sets the top bar of the frame moving synchronously, this motion is imparted to the points of suspension of the other balls, and you see that they all gradually get into swing, and as their swing increases, that of the ball which originated it decreases. This illustrates how heat vibrations are communicated from one body to another, and how the former must necessarily cool in heating that with which it is in contact.

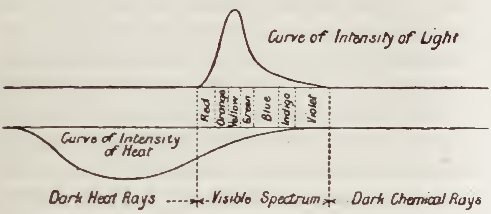
A vibrating string, if it has light substances showered down on it, sets them in motion, but in so doing, it has its own velocity reduced. A string vibrating between rigid supports will continue to sound longer than one attached to a sounding-board, because, in the latter case, much more motion is communicated to the air, the sound is much louder, and hence the motion of the string is more quickly damped. The same action takes place in the communication of heat from one body to another by conduction, or from the hotter portion of one body to a colder portion; the rise in temperature—that is, the increase in the amplitude of vibrations of the colder body—is accompanied by a fall in temperature of the hotter. When such increased motion is communicated, the particles make wider excursions, and generally

cause the body to expand. At last a point is reached at which the bonds of cohesion have been so weakened by the separation of the particles, that they escape from the influence of the other particles they were associated with, and become free to slide over each other, the consequence of which is, that the solid substance becomes liquid. In both these states the violence of motion flings off, as it were, particles at the surface, in consequence of which most solid and liquid substances have a characteristic smell, and many of them, such as snow, ice, and sal ammoniac, evaporate with tolerable rapidity, even at very low temperatures. In the case of liquids, the particles in the mass of the substance are in equilibrium, and move indifferently in any direction; but when a free surface is reached, the outward movement has to take place against the force of gravity so soon as any particle tends to rise above the level of the rest, and hence the tendency of liquids to assume a horizontal free surface. Yet from this surface particles are occasionally projected and escape into the air, assuming the form of vapour; and this escape, as might be expected, is more frequent the more rapid the motion of the particles is, that is to say, the hotter the liquid becomes. In gases, the motion of the particles is similar to that in liquids, but more energetic. They move with great velocity in all directions, striking against each other and against the sides of containing vessels, and rebounding according to the laws of impact of elastic substances, which I have briefly explained. It is the continued bombardment of the sides of the containing vessels by particles extremely minute, inconceivably numerous, and gifted with a stupendous energy, due to their high velocity, which produces the phenomena of pressure and temperature of gases. Were the molecules or atoms perfectly elastic, and were there no friction or resisting medium of any kind, there would be no loss of energy, and hence a gas completely enclosed in a non-conducting vessel would never change its temperature. There is, however, one source of apparent loss of energy, and that is that the innumerable collisions among the particles tend to set up very minute vibrations in the substance of the atoms and molecules themselves, and this action would produce the same effect as in the collision of elastic bodies, where I have already shown that the internal vibrations rendered sensible to us in the form of sound are competent to bring the bodies to rest. In the case of gases, the internal molecular vibrations set up would probably not have the character of sensible heat. All gases are supposed to contain the same number of elastic molecules in the same volume, under similar conditions, hence their specific gravities are proportioned to their atomic weights, and their physical properties are also very much alike, that is to say, they obey the same laws of variation of volume and pressure with respect to heat. The space passed through by a particle of gas without collision is termed the free path. There is a difference in the nature and properties of gases in the three following conditions:—When in contact with the liquids from which they have become disengaged; when completely separated from their liquids; and again when, at high temperatures, dissociation or a subdivision of the molecules takes place, so that when examining a gas, its condition requires to be defined. The evidence of the truth of the molecular theory of liquids and gases is, that they diffuse into each other, that is to say, two different liquids, or two different gases in contact with each other, will mix more or less rapidly, which proves that the particles are free to perform excursions of unlimited extent. Mathematical calculations based on these theories enables us to account for the laws relating to the pressure, temperature, and other properties of liquids and gases.

Although the heat and light-bearing ether is of the nature of a gas, yet vibrations rendered evident as radiant light and heat do not take place in the direction in which the tangible effects seem to travel, but at right angles to them, like a wave travelling along a string, and these vibrations are extremely complex; they are made up, not only of vibrations of various wave lengths vibrating in the same plane, but of vibrations in planes at right angles and other angles to each other. The waves are of inconceivable minuteness and rapidity of motion, else they could not be expected to traverse solid substances. You are doubtless aware that by means of a transparent triangular prism rays of white light can be decomposed, that is to say, the effect of the form of the prism on a ray from a hot body is to separate the various complex vibrations into ones of definite wave lengths. The visible spectrum is bounded by red at one end and violet at the other, but beyond the red, invisible to human eyes, the heat rays spread out, and beyond the violet equally invisible the actinic or chemical rays. The length of a wave of the extreme red is

39,000 to one inch, and of the violet ray 64,631 to one inch. The velocity of light is 186,000 miles a second, hence the red waves strike the retina of the eye at the inconceivable rate of four hundred and sixty millions of millions of times in each second. The analogy between the comparatively coarse motions of sound and those of radiant light and heat are very remarkable, and have, in fact, been the means of leading up to the now well-established undulatory theory. It is well-known that musical sounds extend beyond the compass of the human ear, and that ears are not all alike in respect of their powers of hearing extreme notes at either end of the scale; some people,

FIG. 13.

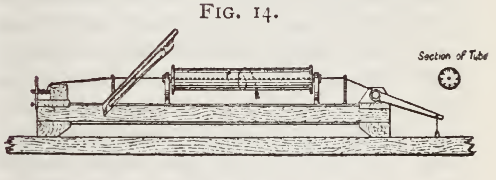


for instance, cannot hear the cry of a bat. The same thing applies to light, we cannot perceive the excessively rapid vibrations beyond the extreme violet of the spectrum, or the comparatively slow movement of the red end, but we can damp the too rapid vibrations by letting the dark rays fall on certain substances, such as sulphate of quinine, and then we are made conscious of fluorescence—light shining out of darkness. You must try and banish from your minds any idea that you may have that there is a substantial difference between rays of heat, of light, or of chemical action. The difference is only one of wave length, and it is due to the structure of our organs of senses that only certain of the vibrations produce the sensation of light, and some of heat, or some produce the impression of light to the eye and heat to the touch. In the case of the actinic rays their superior energy, due to the velocity of motion, may be the cause of their power in decomposing certain substances.

A string made to vibrate, as I have already stated, vibrates in a complex manner, the fundamental note is accompanied by overtones and harmonics; by damping the string in suitable places, the overtones may be extinguished and the fundamental note sounded alone. And so with light and heat. The vibrations in every conceivable plane may be reduced to vibrations in one plane only; this is termed polarisation, and as we have seen that sound waves interfere with each other, so do the waves of heat and light. The irridescent colours seen in soap bubbles, and in thin films generally, are caused by the interference of certain wave lengths reflected from the two sides of the film abolishing certain colours, and destroying the usual whiteness of the light by giving prominence to the complimentary colours.

The diathermancy of substances, that is, their transparency to heat, is so intimately connected with my subject, that I must devote some time to it. It is a matter of every day observation that substances are endowed with varied degrees of transparency, that is to say, that the undulations corresponding to visible rays make their way among the particles of some bodies, and are arrested in whole or in part by others. For example, glass, water, and air, allow the luminous rays to pass with only slightly altered intensity. A certain diminution of energy, indeed, depending upon the thickness of the medium, takes place, as might be expected, from the vibrations having to pass through a crowd of vibrating particles of the substance through which the light is transmitted. Surrounding this monochord, I have placed a tin cylinder with several internal ledges or shelves. It is partially filled with fine sawdust, and as I turn it, the sawdust is

FIG. 14.



showered down upon the string. I now sound the note, and you hear its prolonged cadence gradually dying out. I sound it again, and, at the same time, turn the cylinder, the particles of sawdust, as they fall on the string, are set in motion and the energy so imparted is deducted from the string, consequently you hear that the sound is quickly extinguished. This is analogous to the effect of radiant light and heat passing through substances, the particles of which are capable of responding to the vibration of the ether, and themselves consequently becoming hot at the expense of the radient energy.

The experiment with the swinging balls will serve to illustrate this point. When the

balls were arranged so as to have the same period of oscillation, you saw that they all got into swing. This would represent the case of an adiathermanous body which will not transmit radiant heat, and, therefore, gets hot itself. But if I shorten one or two of the strings, and so give the balls a period of vibration which does not synchronise with that of the swinging ball, you observe that they remain quite unaffected, that is the case of a diathermanous substance which does not get hot itself, but allows the heat rays to pass through.

In the case of light, some substances affect certain wave lengths only and arrest their movement altogether, we then have coloured light such as is produced by coloured glass, liquids and gases. A very large number of substances, when they are of appreciable thickness, will not permit the waves to pass at all, and then we have opaque bodies.

The same rules apply to the heat waves, and what we know of light will lead us to expect that the heat wave will be more interfered with by some bodies than others, and that transparency to light need not be accompanied by transparency to heat, and so we find that transparent rock salt is also diathermanous, whereas glass and water very greatly damp the longer heat waves. Gases vary quite as much as liquids and solids in their effect on radiant heat. Atmospheric air, oxygen, hydrogen, and nitrogen scarcely produce any affect on heat waves, whereas olefiant gas and ammonia interfere with them to a very considerable extent.

The remarkable adiathermancy of water is taken advantage of by diamond cutters and engravers, to concentrate a powerful pencil of light on their work without the accompanying heat. Instead of using glass lenses, they use globular vessels filled with water, which act as water lenses, concentrating the light while they completely cut off the heat. I have seen a firescreen formed by a sheet of water contrived to fall in front of the fire from a slit under the mantlepiece into a trough concealed by the fender.

Our knowledge of the diathermancy of the metals and other substances used in the arts is very limited. Melloni, from whose experiments most of our information is derived, operated mostly on substances more common in the laboratory than in every day life, but we may safely say that all substances are more or less diathermanous, and that the thinner the substances are, the less the heat waves are interfered with.

We are now in a condition to explain many of the phenomena connected with heat.

First, we will take specific heat. It is a matter patent to our senses that there is a great difference in the physical properties of bodies. They differ in specific weight, in strength, in elasticity, in colour, in hardness, and in many other more subtle points, hence we might expect that the atoms or molecules would not be set vibrating with equal facility. We have seen that a force of 10 lbs. acting on a weight of 10 lbs. will produce a definite velocity in a second of time, but if the force of 10 lbs. acts on a weight of 20 lbs. the velocity will be reduced to half, and so it is found that a pound of water, the molecules of which are endowed with energy competent to produce the sensation of 100° Fahr. of heat, if mixed with a pound of water the molecules of which are moving with less energy, and producing the sensation of 50°, the former will lose a portion of their motion while the cold water will gain, the momentum of the two pounds of molecules vibrating at a common velocity will remain the same as the sum of momenta of the respective pounds before mixture, in other words we shall have two pounds of water at 75°. But when the substances mixed together are different, the change of velocity of motion is not so simply arrived at, because not only are the weights of the particles of the two substances different, but the forces which unite them, and which oppose the change of motion, are also different. Thus if 1 lb. of mercury at 100° be mixed with 1 lb. of water at 50°, the result will be a mixture at $53\frac{1}{3}$° only, the reason being that the energy of the vibrations in mercury is only about $3\frac{1}{3}$ per cent. of that of the molecules of water. This relation of the energy of vibrations of various substances to water is called the specific heat of the substance. It has been determined with great care for most bodies, and always takes the form of a decimal fraction, water being unity, for it so happens that water requires more heat to raise it a given number of degrees than any other substance. The specific heat of mercury is ·0333, that of iron ·1138, that of alcohol ·615, that of air ·169, at constant volume. Specific heat in simple substances and in compound bodies of similar atomic composition, is found to vary inversely as the atomic weight, that is to say, the product of the atomic weight into the specific heat is very nearly a constant quantity in the elements and compound bodies of the same order, the said product varying in value with each order.

I have stated that water has been constituted the standard to which specific heats are referred, it is time that I should now explain that the quantity of heat or energy of molecular vibrations which raises one pound of water one degree of Fahrenheit is called the British unit of heat, and because it is a fact that energy is indestructible, so heat, being a form of energy, is also indestructible, it cannot disappear or be lost; hence all calculations connected with heat are based upon the supposition that whatever changes of temperature take place, the total amount of heat units involved will remain unaltered in value, though, perhaps, greatly changed in form. By way of illustration, we will take a very convenient method of measuring very high temperatures. It consists in heating a ball of some refractory metal to the same temperature as that which it is desired to measure, and then, with proper precautions against loss of heat, plunging the ball into water. In order to use this apparatus it is only necessary to know the specific heat of the material of which the ball is composed, its weight, the weight of water into which the ball is plunged, and the increase of temperature in the water. Supposing that a ball of platinum, weighing one pound, had been heated white hot in a furnace, and then plunged into one pound of water at 50°, and that after a time the water had risen to 112°, a simple calculation will show that the ball must have been at a temperature of 2025·3°. The specific heat of platinum is ·0324. Let us now make what Sir Frederick Bramwell calls a debtor and creditor account. Before the ball was quenched we had the following number of heat units:—

In the platinum ball,	2025·3° × ·0324 × 1 lb. =	65·62
In the water	50° × 1 lb =	50
	Total heat units..	115·62

After the ball was quenched, and had got to the same temperature as the water, we had—

In the water	112° × 1 lb. =	112· units.
In the ball	112° × ·0324 × 1 lb. =	3·62 ,,
		115·62

You see the account balances, and it is on that expectation that the formula is based by which the temperature of the ball is calculated.

W = weight of water at temp. t being also that of the air.

W′ = weight of ball.

t' = temperature of ball before quenching.

t'' = temperature of water and ball after quenching.

S = specific heat of ball.

Units of heat in the ball = $W' S \times (t'-t)$.

Units of heat after mixture = $W (t''-t) + W' S \times (t'-t)$.

These two quantities are equal to each other, hence it is easy to work out that t', the temperature of the ball when plunged into the water, will be—

$$t' = \frac{(t''-t)\ (W + W' S)}{W' S} + t.$$

You will find later on that we shall make frequent reference to specific heat.

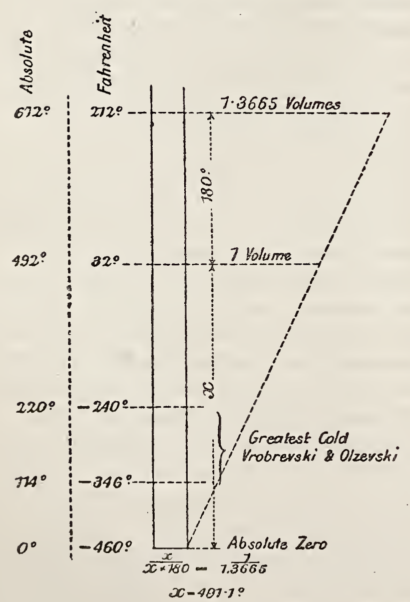
I have already explained how, when the energy of molecular vibration is increased in a solid, the molecules become emancipated from the rigid thraldom in which they were bound, and the solid becomes a liquid. If still more energy be communicated, the liquid becomes a gas.

Now, in the case of accelerated motion, we have seen that as long as the accelerating force acted, the motion of the body acted on continued to increase, but as soon as the accelerating force was diverted and ceased to act, the motion remained uniform, the effect produced by the force remains, according to the first law of motion, though the force has disappeared. So it is with heat motion imparted to a body. So long as the body heated retains its normal form and properties, we can observe the increase of temperature corresponding to an increase of molecular velocity; but as soon as destruction of form begins to take place, the increase of heat no longer becomes sensible, the energy of the force is diverted to breaking up the structure of the body, and to keeping its molecules apart and free to slide over each other. When this has been completely accomplished, and not till then, additional energy imparted again produces an accelerating motion, and the liquid gets hotter and hotter, till at last a second boundary is reached, a second destruction of form takes place, and again the rise of temperature ceases till the whole liquid is transformed into a gas, after which acceleration can again take place and the gas further heated, whereby the energy of its molecules, already very high, is stilled further increased. The heat which apparently disappears during liquefaction and vaporisation is said to be latent, which means no more than that heat, like many persons, cannot do two things at the same time. The work of pulling to pieces the structure of a solid or liquid cannot go on if the mercury in the bulb of a thermometer has to be expanded and made to rise at the same time.

If we wish to restore the substances to their original state, we must arrange matters so that the energy which is keeping the molecules of a body apart shall be diverted to heating some other body, in other words, we must cool the vapour to make it return to the liquid form, and cool the liquid to make it become solid again.

I have spoken of degrees of temperature very often, and have assumed that you understand that the ordinary mercurial thermometer is a contrivance by which the expansion of mercury in a narrow glass tube enables us to measure changes of heat which affect our senses. The two fixed points in a thermometer scale are the melting point of ice and the boiling point of water, and the space between has been divided, in England, into 180°. Fahrenheit, however, to whom we owe our thermometer scale, had an idea that there was a zero point, a point beyond which temperature could not fall, and he fixed it at 32° below the freezing point of water. Fahrenheit was right in his idea, but quite wrong in the zero point he fixed. We have now better grounds upon which to arrive at what is termed the absolute zero of temperature. A perfect gas is found by experi-

Fig. 15.



ment to expand or contract regularly in direct proportion to the alteration of temperature, and the rate of expansion is such that a volume of 1 at the freezing point becomes a volume of 1·3665 at the boiling point, a range of 180°, so that the volume has increased by $\frac{1}{492}$ part for each degree of rise of temperature. On cooling the gas, it is found to contract at the same rate, so that supposing it could be cooled 492° below the freezing point, the gas would occupy no volume at all; and this point is called the absolute zero of temperature; it is 492° below the freezing point, or —460° on Fahrenheit scale. To convert our ordinary degrees into absolute temperature, therefore, we have only to add 460°.

It may be asked whether it is possible that gas deprived of all sensible heat will cease to occupy space; the answer is, that we cannot tell. The lowest temperature reached up to the present time has been attained by the Russian chemists, Wrobrevski and Olsevski, and is 114° on the absolute scale. The absolute zero of temperature can be arrived at also by other means, which it is beyond the scope of these lectures to explain.

Miscellaneous.

*BOXWOOD AND ITS SUBSTITUTES.**

By John R. Jackson, A.L.S.,
Curator of the Museums, Royal Gardens, Kew.

The importance of the discovery of a hard, compact, and even grained wood, having all the characteristics of boxwood, and for which it would form an efficient substitute, cannot be over estimated, and if such a discovery should be one of the results of the present Forestry Exhibition, one of its aims will have been fulfilled. For several years past the gradual diminution in the supplies of boxwood, and the deterioration in its quality, have occupied the attention of hard-wood merchants, of engravers, and of scientific men. Of merchants, because of the difficulties in obtaining supplies to meet the ever-increasing demand; of engravers, because of the higher prices asked for the wood, and the difficulty of securing wood of good size and firm texture, so that the artistic excellence of the engraving might be maintained; and of the man of science, who was specially interested in the preservation of the indigenous boxwood forests, and in the utilisation of other woods, natives, it might be, of far distant countries, whose adaptation would open up not only a new source of revenue, but would also be the means of relieving the strain upon existing boxwood forests.

While by far the most important use of boxwood

* This essay was written for the International Forestry Exhibition at Edinburgh, and was awarded a silver medal.

is for engraving purposes, it must be borne in mind that the wood is also applied to numerous other uses, such, for instance, as weaving shuttles, for mathematical instruments, turnery purposes, carving, and for various ornamental articles, as well as for inlaying in cabinet work. The question, therefore, of finding suitable substitutes for boxwood divides itself into two branches, first, directly for engraving purposes, and, secondly, to supply its place for the other uses to which it is now put. This, to a certain extent, might set free some of the boxwood so used, and leave it available for the higher purposes of art. At the same time, it must not be forgotten that much of the wood used for general purposes is unsuited for engraving, and can only therefore be used by the turner or cabinet-maker. Nevertheless, the application of woods other than box for purposes for which that wood is now used would tend to lessen the demand for box, and thus might have an effect in lowering its price.

So far back as 1875 a real uneasiness began to be felt as to the future supplies of box. In the *Gardeners' Chronicle* for September 25th of that year, page 398, it is said that the boxwood forests of Mingrelia in the Caucasian range were almost exhausted. Old forests, long abandoned, were even then explored in search of trees that might have escaped the notice of former proprietors, and wood that was rejected by them was, in 1875, eagerly purchased at high prices for England. The export of wood was at that time prohibited from Abhasia, and all the Government forests in the Caucasus. A report, dated at about the same period from Trebizonde, points out that the Porte had prohibited also the cutting of boxwood in the crown forests. (*Gardeners' Chronicle*, Aug. 19, 1876, p. 239.) Later on, the British Consul at Tiflis says:—"*Bona fide* Caucasian boxwood may be said to be commercially non-existent, almost every marketable tree having been exported." (*Gardeners' Chronicle*, Dec. 6, 1879, p. 726.)

The characters of boxwood are so marked and so distinct from those of most other woods, that some extracts from a report of Messrs. J. Gardner and Sons, of London and Liverpool, addressed to the Inspector-General of Forests in India, bearing on this subject, will not be without value; indeed, its more general circulation than its reprint in Mr. J. S. Gamble's "Manual of Indian Timbers" will, it is hoped, be the means of directing attention to this very important matter, and by pointing out the characters that make boxwood so valuable, may be the means of directing observation to the detection of similar characters in other woods. Messrs. Gardner say:—

"The most suitable texture of wood will be found growing upon the sides of mountains. If grown in the plains the growth is usually too quick, and consequently the grain is too coarse, the wood of best texture being of slow growth, and very fine in the grain.

"It should be cut down in the winter, and, if possible, stored at once in airy wooden sheds well protected from sun and rain, and not to have too much air through the sides of the sheds, more especially for the wood under four inches diameter.

"The boxwood also must not be piled upon the ground, but be well skidded under, so as to be kept quite free from the effects of any damp from the soil.

"After the trees are cut down, the longer they are exposed the more danger is there afterwards of the wood splitting more than is absolutely necessary during the necessary seasoning before shipment to this country.

"If shipped green there is great danger of the wood sweating and becoming mildewed during transit, which causes the wood afterwards to dry light and of a defective colour, and in fact rendering it of little value for commercial purposes.

"There is no occasion to strip the bark off or to put cowdung or anything else upon the ends of the pieces to prevent their splitting.

"Boxwood is the nearest approach to ivory of any wood known, and will, therefore, probably gradually increase in value, as it, as well as ivory, become scarcer. It is now used very considerably in manufacturing concerns, but on account of its gradual advance in price during the past few years cheaper woods are in some instances being substituted.

"Small wood under 4 inches is used principally by flax spinners for rollers, and by turners for various purposes, rollers for rink skates, &c., &c., and if free from splits, is of equal value with the larger wood. It is imported here as small as $1\frac{1}{2}$ inches in diameter, but the most useful sizes are from $2\frac{1}{2}$ to $3\frac{1}{2}$ inches, and would therefore, we suppose, be from 15 to 30 or 40 years in growing, whilst larger wood would require 50 years and upwards at least, perhaps we ought to say 100 years and upwards. It is used principally for shuttles, for weaving silk, linen, and cotton, and also for rule making and wood engraving. *Punch*, *The Illustrated London News*, *The Graphic*, and all the first-class pictorial papers use large quantities of boxwood."

In 1880, Messrs. Churchill and Sim reported favourably on some consignments of Indian boxwood, concluding with the remarks, that if the wood could be regularly placed on the market at a moderate figure, there was no reason why a trade should not be developed in it. Notwithstanding these prospects, which seemed promising in 1877 and 1880, little or nothing has been actually done up to the present time in bringing Indian boxwood into general use, in consequence, as Mr. Gamble shows, of the cost of transit through India; the necessity, therefore, of the discovery of some wood akin to box is even more important now than ever it was.

Boxwood Substitutes.

First amongst the substitutes that have been proposed to replace boxwood, may be mentioned an invention of Mr. Edward Badoureau, referred to in

the *Gardeners' Chronicle*, March 23rd, 1878, p. 374, under the title of artificial boxwood. It is stated to consist of some soft wood, which has been subject to heavy pressure. It is stated that some English engravers have given their opinion on this prepared wood as follows:—It has not the power of resistance of boxwood, so that it would be impossible to make use of it, except in the shape of an electro obtained from it, as it is too soft to sustain the pressure of a machine, and would be easily worn out. In reply to these opinions, Mr. Badoureau wrote:—"My wood resists the wear and tear of the press as well as boxwood, and I can show engravings of English and French artists which have been obtained direct from the wood, and are as perfect as they are possible to be; several of them have been drawn by Mr. Gustave Doré."

Mr. Badoureau further says, "that whilst as an engraver he has so high an opinion of the qualities of compressed wood as a substitute for boxwood, as the inventor of the new process, he considered that it possesses numerous advantages both for artistic and industrial purposes." In short, he says, "my wood is to other wood what steel is to iron."

The following woods are those which have, from time to time, been proposed or experimented upon as substitutes for boxwood, for engraving purposes. They are arranged according to their scientific classification in the natural orders to which they belong:—

Natural Order Pittosporeæ.

1. *Pittosporum undulatum*, Vent.—A tree growing in favourable situations to a height of 40 or even 60 feet, native of New South Wales and Victoria. It furnishes a light, even-grained wood, which attracted some attention at the International Exhibibion in 1862; blocks were prepared from it, and submitted to Prof. De la Motte, of King's College, who reported as follows:—"I consider this wood well adapted to certain kinds of wood engraving. It is not equal to Turkey box, but it is superior to that generally used for posters, and I have no doubt that it would answer for the rollers of mangles and wringing machines." Mr. W. G. Smith, in a report in the *Gardeners' Chronicle* for July 26th, 1873, p. 1017, on some foreign woods which I submitted to him for trial, says that the wood of *Pittosporum undulatum* is suitable only for bold outlines; compared with box, it is soft and tough, and requires more force to cut than box. The toughness of the wood causes the tools to drag back, so that great care is required in cutting to prevent the lines clipping. The average diameter of the wood is from 18 to 30 inches.

2. *Pittosporum bicolor*, Hook.—A closely allied species, sometimes forty feet high, native of New South Wales and Tasmania. This wood is stated to be decidedly superior to the last-named.

3. *Bursaria spinosa*, Cav.—A tree about forty feet high, native of North, South, and West Australia, Queensland, New South Wales, Victoria, and Tasmania, in which island it is known as boxwood. It has been reported upon as being equal to common or inferior box, and with further trials might be found suitable for common subjects; it has the disadvantage, however, of blunting the edges and points of the tools.

Natural Order Meliaceæ.

4. *Swietenia mahagoni*, L. (Mahogany).—A large timber tree of Honduras, Cuba, Central America, and Mexico. It is one of the most valuable of furniture woods, but for engraving purposes it is but of little value, nevertheless it has been used for large coarse subjects. Spanish mahogany is the kind which has been so used.

Natural Order Ilicineæ.

5. *Ilex Opaca*, L. (North American Holly).—It is a widely diffused tree, the wood of which is said to closely resemble English holly, being white in colour, and hard, with a fine grain, so that it is used for a great number of purposes by turners, engineers, cabinet-makers, and philosophical instrument makers. For engraving purposes it is not equal to the dogwood of America (*Cornus florida*); it yields, however, more readily to the graver's tools.

Natural Order Celastrineæ.

6. *Elæodendron australe*, Vent.—A tree twenty to twenty-five feet high, native of Queensland and New South Wales. The wood is used in the colony for turning and cabinet work, and Mr. W. G. Smith reports that for engraving purposes it seems suitable only for rough work, as diagrams, posters, &c.

7. *Euonymus Sieboldianus*, Blume.—A Chinese tree, where the wood, which is known as Pai'cha, is used for carving and engraving. Attention was first drawn to this wood by Mr. Jean Von Volxem, in the *Gardeners' Chronicle* for April 20th, 1878. In the Kew report for 1878, p. 41, the following extract of a letter from Mr. W. M. Cooper, Her Majesty's Consul at Ningpo, is given:—"The wood in universal use for book blocks, wood engravings, seals, &c., is that of the pear tree, of which large quantities are grown in Shangtung, and Shan-se, especially. Pai'cha is sometimes used as an indifferent substitute. Pai'cha is a very fine white wood of fine fibre, without apparent grains, and cuts easily; is well suited for carved frames, cabinets, caskets, &c., for which large quantities are manufactured here for export. The tree itself resembles somewhat the *Stillingia*, but has a rougher bark, larger and thinner leaves, which are serrated at the edge, more delicate twigs, and is deciduous." In 1879, a block of this wood was received at Kew Museum, from Mr. Cooper, a specimen of which was submitted to Mr. Robson J. Scott, of Whitefriars-street, to whom I am much indebted for reports on various occasions, and upon this wood Mr. Scott reported as follows:—"The most striking quality I have observed in this wood is its capacity for retaining water, and the facility with

which it surrenders it. This section [one prepared and sent to the Kew Museum], which represents one-tenth of the original piece, weighed 3 lbs. 4½ ounces. At the end of twenty-one days it had lost 1 lb. 6¾ ounces in an unheated chamber. At the end of another fourteen days, in a much elevated temperature, it only lost ¼ ounce. In its present state of reduced bulk its weight is 1 lb. 10 ounces. It is not at all likely to supersede box, but it may be fit for coarser work than that for which box is necessary." Later on, namely in the Kew report for 1880, p. 51, Mr. R. D. Keene, an engraver, to whom Mr. Scott submitted specimens of the wood for trial, writes:—"I like the wood very much, and prefer it to box in some instances; it is freer to work, and consequently quicker, and its being uniform in colour and quality is a great advantage; we often have great difficulty in box in having to work from a hard piece into a soft. I think it a very useful wood, especially for solid bold work, I question if you could get so extreme a fine black line as on box, but am sure there would be a large demand for it at a moderate price." Referring to this letter, Mr. Scott remarks that the writer does not intend it to be understood that Pai'cha is qualified to supersede box, but for inferior subjects for which coarse brittle box is used. Mr. Scott further says that of the woods he has tried he prefers pear and hawthorn to Pai'cha.

(To be continued).

ORANGES IN PALESTINE.

Consul Merrill, of Jerusalem, states, in his last report on fruit cultivation in Palestine, that the orange groves in that country are confined chiefly to Jaffa and Gaza, and are situated near the sea coast. The trees appear to flourish best near the sea, the beach sand mingled with alluvial soil being best adapted to their growth. There are, in Jaffa alone, no less than 500 different gardens, containing, altogether, about 800,000 trees, both large and small. Of these gardens, 150 are ranked as first-class, while the others are ranked as second and third rate in size and production. The trees are planted about 15 feet apart, although there is no regularity or exactness on the part of the natives in planting them. In July or August, cuttings are made from the sweet lemon trees each about 18 inches long, and these are planted in beds and watered twice a day. They grow rapidly and in the second year they are budded. When the bud has taken, the lemon stalk is cut off, a few inches above the bud, and the new shoots begin to bear in the third or fourth year. The trees continue bearing for twenty or thirty years. During the summer every tree is watered once a week, and in some cultivations it is a rule to water the trees every fifth day. Water is brought to the surface from a depth of twenty-five or thirty feet, by means of horse power, the owner of the garden employing for this work horses, donkeys, or camels. The cost of irrigation, with which it is customary to reckon the other expenses that are necessary to keep the ground in order, is estimated at about one-fifth of the value of the crop in gardens of the first class, while in the inferior gardens it amounts to one-third, and sometimes one-half of the value of the crop. The orange trees in Palestine do not suffer from any noxious insects, fungus growth, or diseases of any kind, and both the climate and soil are admirably adapted to produce healthy trees. In planting, the ground between the trees is generally cultivated, small fruits, or vegetables being grown where the branches of the trees do not touch each other. Interspersed among the orange trees are frequently seen palm trees, bananas, the apple, peach, plum, pear, apricot, or fig, and occasionally the mulberry and sycamore. The average cost to the producer of 1,000 oranges is estimated to be about 21s., and capital invested in orange gardens is expected to return between 12 and 15 per cent. For 1,000 oranges it is customary to reckon 1,500, so that after they are assorted, the purchaser will have, out of 1,500, 1,000 that are fit for exportation. They are consigned in large quantities to Europe, and among the different markets, that of Odessa is becoming the most important for Jaffa oranges. Thousands of boxes are also annually sent to London. Consul Merrill says that besides the Jaffa orange proper, which is the only description exported, and is of oval or lemon shape, and very large, there is another kind cultivated in Palestine. This grows upon trees that are grown directly from the seed of the orange, without budding or grafting. They are small, and of inferior quality, and are all consumed at home.

MINING ACCIDENTS IN EUROPE.

M. Simonin has recently published, in the *Journal de la Société de Statistique de Paris*, a review of the mining accidents in the principal European countries, and says that, according to the statistical records of the mining industries issued by the French Ministry of Public Works, the average annual number of miners in France during the period 1872-1881 amounted to 105,742, while the number killed was 222, and injured, 1,369, or a proportion of 2·09 deaths, and 12·94 accidents to every thousand persons employed, fire damp, in nearly all cases, being the cause of the accidents. In England, according to the reports of the Inspector of Mines, or the decennial period 1873-1882 the average number of persons annually employed amounted to 558,817, 500,000 in coal mines, and the remainder in metalliferous mines. The annual number of accidents averaged 9·47, and the number of deaths 2·18 per thousand, or one death to every 458 miners. In 1882, of the 1,218 miners killed, 250, or 20 per cent., were the victims of gas explosions or fire damp. As regards Belgium, the average number of miners was

76,697 in the decade 1872-1881, and the number of accidents 146, and deaths 83, or a proportion of 2·38 per thousand, this being a quarter per cent. higher than the English death-rate, which was 2·18 per thousand. In the coal mines of the district of Liège the returns for the period of 1876-1881 gave a total of 80 deaths and 152 serious accidents to every thousand miners. In calling attention to the variations in the proportions of deaths and accidents in England, France, and Belgium, M. Simonin points out that the rate is lower in France than in either of the other countries, and says that it may be accounted for by the fact that in France there is a stricter system of supervision exercised by the Government over mining industries; and the system of management and working of the mines generally is, technically speaking, of a much superior order. In Prussia, according to a report on mining accidents, prepared in 1883 by M. Hasslacher, the official mining administrator, the proportion of miners killed in the decennial period 1871-1880, averaged 2·89 per thousand, or one in every 345, and thus it will be seen that the death-rate is considerably higher than that of France, England, or Belgium. In Austro-Hungary it is estimated that in the quinquennial period comprised between the years 1875 and 1880, the number of miners employed in the coal mining industries averaged 41,133, and the number of deaths did not exceed 8,631, or 2·10 per thousand, this being a lower proportion than is to be found in any of the other countries above mentioned.

Correspondence.

MUSICAL SCALES.

The following corrections should be made in my paper, "On the Musical Scales of Various Nations":—

Page 501, col. 1, 5th line above the OLD C-SCALE, for "to which they were communicated by the Rajah," read "drawn up from indications furnished by the Rajah."

Page 524, col. 1, lines 8 to 11, for "I suppose——" down to "the string," read "by taking hold of the string beyond the bridge and pulling it towards the bridge, thus reducing the tension of the portion played on."

ALEXANDER J. ELLIS.

April 7, 1885.

EXPLORATION.

That section of the paper on "Exploration," by Major-General Feilding, which treats of the means of locomotion, will command the attention of every practical coach and harness maker who is fortunate enough to read it. In essence, the General's ideas coincide with the opinions of men who have made carriage construction the study and business of their lives, but there are some few points in which his views are somewhat opposed to the experience of English coachbuilders; and although lacking the authority of an explorer to speak in such matters, an experience of thirty years in the construction of carriages for foreign climates induces me to address you on the subject.

I observe that in many cases, General Feilding prefers a combination of wood and iron, to iron alone. In some parts of the body and undercarriage such a combination is the best, and I have found that, weight for weight, it is the most suitable for bearing such sudden shocks and jerks as we may reasonably suppose are common in exploring expeditions. Wheels 4 ft. 2 in. in height, and having the horses drawing from the front axle (which is connected with the hind one by a perch), are evident advantages in reducing draught. As the weight in these wagons will presumably be equally borne by each axle, the wheels should be equal in height, as the draught is then easier than with wheels of varying heights.

The Grasshopper spring which the General recommends (in conjunction with india-rubber buffers, which counteract sudden and exceptional deflection of the spring), has proved the most suitable for the largest class of vehicle, such as brakes and *char-a-bancs*, which carry from 20 to 30 passengers. It can be made of any desired strength, while (by its length), the action is always soft and easy.

The common axle referred to is, I expect, either the Leeds or the mail pattern. The mail and Leeds axles were both used in mail coaches running 120 and 130 miles a day with heavy loads on bad roads, and some of these coach wheels were known to run 4,000 miles without repairs.

In speaking of wheels, General Feilding has opened up a subject of surpassing importance to coachmakers. His remarks lead me to the conclusion that the wheels he speaks of were neither produced by good workmen nor from good materials.

That a wheel should be made from timber grown in the country where it is used can easily be understood, but this is not always possible.

Accepting the General's definition of seasoned timber, it is my opinion that if the wheels are properly proportioned, and suitable for carrying a given weight, if the spokes are cloven (not sawed), and they are made by a good firm, the troubles which necessitate caulking the gaps with white lead, cotton waste, &c., would, with prudence, be prevented. A great deal of the mischief may be traced to the fact that the spoke ends rest upon the axle-box, a non-metallic surface.

In preference to the Sarden, Warner, or any other patent wheel at present in the market, I would favour a wood one, having a rock elm hub (only morticed deep enough for the spoke tenons, between which and the axle-box the substance of the hub

should be left intact) or one of Fustic, cloven spokes of the best English or Scotch oak, and felloes (which can be more readily replaced than a bent rim) of the toughest young ash. Hickory is an over-rated timber. It is not such a good spokewood as English oak. It absorbs moisture more readily, nor is it so strong. The mortices in the hub must be accurately cut, and the spokes driven tightly, with a little linseed oil rubbed on the tenons if necessary, and they will require neither white lead or any such medium for fixing them. Steeping the wheel in water overnight is a ready way of counteracting the contraction that takes place during the day, but the repeated expansion and contraction must eventually ruin it.

The General's suggestion, that the tire should be slightly convex on the inner surface, fitting a corresponding concavity in the rim, is not unknown to coachmakers in this country. The difficulty of keeping the tire tight is more readily overcome by giving the wheels more disk, as in use they become more upright.

General Feilding rightly says that when the tire is repaired by clipping to the rim, the action of the brake blocks is interfered with; but if a nave brake, such as Mortimer's, were used, this difficulty would not exist. This brake will doubtless come into more general use as its merits are recognised, and it possesses one advantage upon which the General lays considerable stress, viz., the property of completely stopping the revolution of the wheels, removing the necessity for skids.

As to harness. The only advantage of the breast collar is that it will fit horses of varying sizes, but on no other grounds should it be used. A horse's power is simply wasted by the breast strap; it impedes both his respiration and muscular action. A neck collar is the best on good roads, then its value must be greater on bad ones. I have hitherto regarded bark-tanned leather as the best material (not only for strength, but durability) for harness, and I am at a loss to understand how the genuine article can be so very much affected by the weather.

All saddles and collars for use in hot climates should be lined with flannel, which absorbs the sweat and prevents sores; but if they do appear, then the simplest plan is, as General Feilding recommends, to remove a piece of the lining corresponding in size to the affected part, so that it may not be irritated. If cart and cab-drivers in this country only realised the value of this simple plan, the duties of the inspectors of the R.S.P.C.A. would be considerably lightened.

JOHN PHILIPSON.

Newcastle-on-Tyne.

General Notes.

EUROPEAN INDUSTRIES IN JAPAN.—A correspondent of the *Bund* calls attention to the fact that various industries, essentially of European character, are now firmly established in Japan. The requirements of the country for inflammable ware are now exclusively covered by the domestic manufacture of the article. The soap industry has lately made important progress, and even the better descriptions (such as glycerine and toilet soaps) are made in Japan.

ROYAL INSTITUTION. — The following lecture arrangements for the meetings after Easter have been made :—Professor Gamgee, eight lectures, on Digestion and Nutrition, on Tuesdays, April 14 to June 2; Professor Tyndall, five lectures, on "Natural Forces and Energies," on Thursdays, April 16 to May 14; Professor Meymott Tidy, three lectures, on "Poisons in relation to their Chemical Constitution and to Vital Functions," on Thursdays, May 21, 28, June 4; Mr. W. Carruthers, four lectures, on "Fir-trees and their Allies, in the Present and in the Past," on Saturdays, April 18 to May 9; Professor Odling, two lectures, on "Organic Septics and Antiseptics," on Saturdays, May 16, 23; and Rev. C. Taylor, two lectures, on a "Lately Discovered Document, possibly of the first century, entitled 'The Teaching of the Twelve Apostles,'" with illustrations from the Talmud. The Friday evening meetings will be resumed on April 17, when Professor S. P. Langley, of the Allegheny Observatory, Pennsylvania, will give a discourse on "Sunlight and the Earth's Atmosphere."

MEETINGS OF THE SOCIETY.

APRIL 15.—"Removal of House Refuse Independent of Sewage." By B. W. RICHARDSON, M.D., F.R.S.

"Abolition of Water Carriage in the Removal of Effete Organic Matter from Towns." By THOMAS HAWKESLEY, M.D.

APRIL 22.—"Technical Education." By HENRY CUNYNGHAME, Assistant Charity Commissioner.

APRIL 29.—"Researches on Silk Fibre." By THOMAS WARDLE.

MAY 6.—

MAY 13.—"A Marine Laboratory as a Means of Improving Sea Fisheries." By Professor E. RAY LANKESTER, M.A., F.R.S.

MAY 20.—"The American Oil and Gas-fields." By Professor JAMES DEWAR, F.R.S.

INDIAN SECTION.

Friday evenings at Eight o'clock.

APRIL 17.—"The Parsis and the Trade of Western India." By JEHANGEER DOSABHOY FRAMJEE. Field-Marshal LORD NAPIER OF MAGDALA, G.C.B., G.C.S.I., will preside.

MAY 8.—"The Ancient and Modern Methods of Treating Epidemics of Small-pox in India." By ROBERT PRINGLE, late Sanitary Department H.M. Bengal Army. Sir PHILIP CUNLIFFE-OWEN, K.C.M.G., C.B., C.I.E., will preside.

MAY 15.—"The Golden Road to South-Western

China." By R. K. Douglas, Professor of Chinese at King's College, London. The Hon Edward Stanhope, M.P., will preside.

Foreign and Colonial Section.

Tuesday evenings at Eight o'clock.

April 14.—"British Interests in East Africa, especially in the Kiliman'jaro District." By H. H. Johnston.

April 28.—"The Federation of the Empire." By J. E. Gorst, M.P. The Right Hon. W. E. Forster, M.P., will preside.

May 19.—"New Britain and the Adjacent Islands." By Wilfred Powell. Sir Francis Dillon Bell, Member of Council, will preside.

Applied Chemistry and Physics Section.

Thursday evenings at Eight o'clock.

April 23.—"The Chemistry of Ensilage." By Frederick J. Lloydd.

The dates given above are subject to alteration.

Cantor Lectures.

The Sixth Course, "Photography and the Spectroscope." By Captain C. W. de W. Abney, R.E., F.R.S.

April 20 and 27.

The Seventh and concluding Course, "The Manufacture of Toilet Soaps." By C. R. Alder Wright, D.Sc., F.R.S., F.C.S.

May 4, 11, and 18.

Admission to Meetings.

Members have the right of attending all the Society's meetings and lectures. Every member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the members, but admission can also be obtained on the personal introduction of a member.

MEETINGS FOR THE ENSUING WEEK.

Monday, April 13 ..Engineers, Westminster Town Hall, S.W., 7½ p.m. Mr. J. Dixon Gibbs, "The Distribution of Electrical Energy by Secondary Generators."

Chemical Industry (London Section), Burlington-house, W., 8 p.m. Mr. W. J. Dibdin, "Further Notes on the 'Radial' Photometer and the proposed Standards of Light."

Geographical, University of London, Burlington-gardens, S.W., 8½ p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Rev. George Blencowe, "Human Responsibility."

Tuesday, April 14 ..SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Mr. H. H. Johnston, "British Interests in East Africa, particularly in the Kiliman'jaro District."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Arthur Gamgee, "Digestion and Nutrition." (Lecture V.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. W. Shelford, "Rivers Running into Tideless Seas, illustrated by the River Tiber."

Photographic, 5a, Pall-mall East, S.W. 8 p.m.

Anthropological, 3, Hanover-square, W., 8 p.m. Dr. J. G. Garson, "The Inhabitants of Tierra del Fuego."

Colonial Inst., Grosvenor Gallery Library, 136, New Bond-street, W., 8 p.m.

Wednesday, April 15...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. 1. Dr. B. W. Richardson, "Removal of House Refuse independently of Sewage." 2. Dr. Thomas Hawkesley, "Abolition of Water Carriage in the Removal of Effete Organic Matter from Towns."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. "Report of Committee on Decrease of Water Supply." 2. "Report of Committee on the Helm Wind of Cross Fell, Cumberland." 3. Mr. Richard Strachan, "Results of Meteorological Observations made at Asuncion, Paraguay."

Geological, Burlington-house, W., 8 p.m. 1. Rev. A. Irving, "A General Section of the Bagshot Strata from Aldershot to Wokingham." 2. Mr. G. R. Vine, "Notes on the Polyzoa and Foraminifera of the Cambridge Greensand."

Hospitals Association, 1, Adam-street, Adelphi, W.C., 8 p.m. Fifth General Meeting. Capt. William Joynson, "Horse Ambulances in Connection with Hospitals."

Archæological Association, 32, Sackville-street, W., 8 p.m. Mr. E. Maunde Thompson, "Archbishop Ælfric's Vocabulary."

Thursday, April 16...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Sir John Lubbock, "Forms of Leaves." 2. Professor F. Jeffrey Bell, "New Species of Australian Minyad." 3. Jas. J. White, "Germination of Seeds after long submersion in Salt Water."

Chemical, Burlington-house, W., 8 p.m.

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. G. Aitchison, "Architecture in the 19th Century."

Royal Institution, Albemarle-street, W., 8 p.m. Prof. Tyndall, "Natural Sources and Energies.' (Lecture I.).

Historical, 11, Chandos-street, W., 8 p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Special Lecture. "The Theory and Practice of Hydro-Mechanics." Mr. Thomas Stevenson, C.E., "Tides and Coast-Works."

Numismatic 4, St. Martin's-place, W.C., 7 p.m.

Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Mrs. Sheil, "Physiology and the Laws of Health." (Lecture VII.). "Clothing."

Friday, April 17 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. Jehangeer Dosabhoy Framjee, "The Parsis and the Trade of Western India."

Philological, University College, 8 p.m. "The Plural Number of the Languages of Central Africa," by the late Dr. Balfour Baikie, with comments by Dr. R. G. Latham.

Saturday, April 18...Royal Institution, Albemarle-street, W., 3 p.m. Mr. W. Carruthers, "Fir Trees and their Allies." (Lecture I.)

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No. 1,691. Vol. XXXIII.

FRIDAY, APRIL 17, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

INTERNATIONAL INVENTIONS EXHIBITION SEASON TICKETS.

The Executive Council of the International Inventions Exhibition have consented to allow Members of the Society of Arts the privilege of purchasing Season Tickets for the Exhibition at half-price (10s. 6d.) Any member desiring to avail himself of the privilege can obtain a ticket by applying to the Secretary, and remitting the price, 10s. 6d. Each member will only be allowed the privilege of purchasing a single ticket on these terms, which will be a personal admission, not transferable. It will be understood that all applications must be accompanied by the above-named remittance, and that tickets at the reduced rate can only be obtained from the Secretary of the Society.

Season tickets admit to the opening ceremony on Monday, 4th May.

Proceedings of the Society.

HOWARD LECTURES.

ON THE CONVERSION OF HEAT INTO USEFUL WORK.

By William Anderson, M.Inst.C.E.

Lecture III.—Delivered Dec. 12th, 1884.

We have now to consider the properties of gases and vapours. I have already explained that aeriform substances exist in different conditions: first, near the temperatures and pressures at which they separate from their liquids, when the temperature of the gas and liquid from which it is formed is the same, when the energy of motion of some of the molecules in the liquid is constantly being raised to a pitch which causes them, under favourable conditions of position and direction of motion, to leave the liquid and escape into the free space above. Suppose the bob of a pendulum could be set free at the moment when it reaches its lowest point or point of maximum kinetic energy, the bob would continue to move at a uniform velocity for ever, and being perfectly elastic, if surrounded by equally elastic walls and other particles, would continue to strike and rebound from them in all directions. An ordinary pendulum continues to swing to and fro, the energy of both is the same, only it is all kinetic in the free bob and perpetually changing from kinetic to potential in the pendulum; and so it is when a solid passes into a liquid, the average energy of the molecules is the same, but in the solid the excursions of the particles are limited by the force of cohesion, while in the liquid there is no such limit; therefore, as the temperature depends on the energy of motion, it must be the same in the solid and liquid while the change is taking place. In the case of liquids and gases, the motion of the molecules is similar in character, but the average motion in liquids is less than in gases, though it often happens that some molecules of a liquid attain a higher velocity than the average motion of the molecules of a gas, and in such cases they may, under favourable circumstances of position, detach themselves from the liquid and become parts of the gas, and, on the other hand, some of the molecules of a gas may have less motion than the average of those of the liquid, and would, therefore, on coming in contact with it, revert to the fluid condition.

If the molecules of the vapours are brought nearer together, when in this critical state, by compression, some of them have their excursions shortened till they again come within the power of attraction, and the vapour becomes in part a liquid, so that the pressure cannot be sensibly raised without a preliminary increase of temperature. This critical point varies greatly in different substances. Oxygen, for example, at 252° Fahr. below the freezing point, or at 240° Fahr. on the absolute scale, liquefies under a pressure of 320 atmospheres or 2·1 tons per square inch, while hydrogen, at the same temperature, requires more than double the pressure, or 650 atmospheres, corres-

ponding to 4·3 tons per square inch. Carbonic acid gas liquefies at a temperature of 88° Fahr. under a pressure of 75 atmospheres. The substances seem to be in a condition between the liquid and gaseous, the molecules being so packed together in proportion to their energy of motion, that some are under the influence of cohesion and others darting about unrestrained.

The volume, pressure, and temperature of gases, far removed from their points of condensation, have certain relations to each other defined by the laws of Boyle or Mariotte, and Charles or Gay-Lussac.

According to Boyle's law, the product of the volume (v) and pressure (p) of a gas is always a constant quantity at the same temperature, that is to say, if you reduce a given volume of gas to half its bulk by external pressure, and arrange so that the temperature shall not change, then the pressure will be doubled. This relation is thus expressed $p\,v = p_1\,v_1$. According to the laws of Charles, the pressure of a gas confined in a fixed space, and the volume of a gas free to expand, will vary as the absolute temperature,

$$\frac{p\,v}{p_1\,v_1} = \frac{t}{t_1}$$

Suppose 1 cubic foot of gas at 50° or 510° absolute, what will be the volume at 212°, or 672° absolute, if there is no change of pressure? The answer is

$$\frac{1 \times 672}{510} = 1·31 \text{ cubic feet.}$$

Suppose 1 cubic foot of air at 510° and 100 lbs. absolute pressure, compressed to half its volume and heated to 212° or 672° absolute, what will be the pressure?

$$\frac{100 \text{ lbs.} \times 1 \text{ c. ft.}}{p_1\ 1 \times ·5 \text{ c. ft.}} = \frac{510°}{672°}$$

$$\therefore p_1 = \frac{100 \text{ lbs.} \times 1 \times 672}{510° \times ·5} = 263·5 \text{ lbs.}$$

If $v\ p\ t$ represent volume pressure and absolute temperature, and $v_1\,p_1\,t_1$ the volume pressure and temperature of the same weight of gas under other circumstances.

$$\text{Boyle law gives } v\,p = v_1\,p_1$$

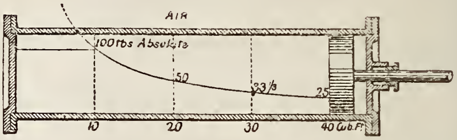
$$v_1 = \frac{v\,p}{p_1} \text{ and } p_1 = \frac{v\,p}{v_1}$$

from which the volume and pressures at constant temperature may be ascertained, and because both the volume and the pressure vary as the absolute temperature, then, when there is a change of temperature,

$$v_1 = \frac{v\,p}{p_1}\frac{t_1}{t} \text{ and } p_1 = \frac{v\,p}{v_1}\frac{t_1}{t}$$

The properties of a gas may be graphically exhibited by means of a curve.

FIG. 16.



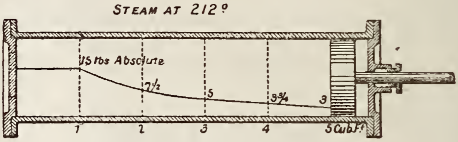


FIG. 17.

Suppose a cylinder fitted with an air-tight piston, and that 10 cubic feet of air at 100 lbs. absolute pressure, that is, pressure measured from a perfect vacuum, were imprisoned between it and the end of the cylinder. If the piston were drawn out, equal distances would represent equal volumes, so that the length of stroke would be proportional to the volumes assumed by the gas. On the diameter of the cylinder set off a length proportional to 100 lbs. pressure, and let the temperature be kept constant at, say, 60°, then, according to Boyle's law, when the volume had doubled, or increased to 20 cubic feet, the pressure would be halved, or only 50 lbs. When the volume increased to 30 cubic feet, the pressure would be only 33⅓ lbs., and so on. You will notice from the diagram (Fig. 16) that the curve of pressures keeps getting nearer and nearer to the zero or base line, but inasmuch as we can never, by division, reduce anything to nothing, it follows that any amount of expansion can never annihilate the pressure altogether, though it may reduce it to less than anything we can name. The curve we have traced is called an isothermal line, because the gas throughout is assumed to be at the same temperature. The action I have described is reversible, that is to say, when the motion of the piston is reversed, the gas will be compressed, and the pressure will form ordinates to the same curve if there be no change of temperature.

But if the gas operated on is near its point of liquefaction, matters are not so simple. Such a gas we have in steam. Let us suppose a cylinder 5 feet long, filled with steam at 3 lbs. absolute pressure, and 212° temperature. If the piston were pushed in, the pressure would rise nearly, according to the

isothermal curve, until a pressure of 15 lbs. or one atmosphere was reached, and then we should attain a pressure and temperature at which water may exist either as a liquid or a gas. The slightest increase of pressure causes the steam to condense, and therefore the isothermal line will cease to be a curve, but will be a line parallel to the base, indicating that there will be no further rise of pressure till all the steam is condensed. When that happens, there will be less than a 7,000th part of the original bulk of steam reduced to water at 212° temperature, and practically uncompressible. The reverse action would take place supposing the minute volume of water were kept at 212° while the piston was drawn slowly out, the water would boil away and would all become steam by the time the first foot had been passed over, aud then the pressure would diminish according to the law of Boyle.

It is not easy, in treating of the conversion of heat into work, to arrange the subject so as not to ask you to take for granted what has not been first explained; and in order to avoid committing such an offence, I must for a time, leave the behaviour of gases under varying pressures and temperatures, and direct your attention to the mechanical equivalent of heat. Less than ninety years ago, it was an inexplicable puzzle whence came the heat developed, apparently without limit, and without change in the properties of matter, in certain mechanical operations. Count Rumford noticed the circumstance in the boring of cannon, and in 1798 laid before the Royal Society a description of the famous experiment from which he deduced that heat must be motion of some kind, and even made an approximation of its mechanical equivalent. Sir Humphry Davy succeeded in melting ice in an atmosphere at 29° by rubbing two slabs over each other, producing water at a temperature of 35°; and he announced the important proposition, that "the immediate cause of the phenomenon of heat is motion, and the laws of its communication are precisely the same as the laws of the communication of motion." Our more extended knowledge enables us to confirm the views expressed by Davy, and it is for this reason that I commenced these lectures by briefly reminding you of Newton's laws of motion.

About thirty-five years ago Joule determined, by direct experiment, the mechanical equivalent of heat, and it is now accepted as 772 foot-pounds, which means that the energy represented by the fall of 772 lbs. one foot is the same as that necessary to change the temperature of one pound of water one degree Fahrenheit. Joule's equivalent, as it is called, is known in mechanics by the letter J. We are now enabled to enunciate the first law of thermo-dynamics, which is, that "heat and mechanical energy are mutually convertible, and heat requires for its production, or produces by its disappearance, mechanical energy in the proportion of 772 foot-pounds for each unit of heat." It seems strange that, although instances of the conversion of heat into work and the opposite are so common, that the relation between the two forms of energy was not earlier suspected. The heat produced by friction, by hammering, by the sudden stoppage of bullets, were phenomena familiar to all; the constant application of heat to produce power in heat-engines, though not so obvious, was an operation which might have led inquiring minds to suspect that the source of power was not the steam, but the heat developed by the fuel.

The establishment of the dynamic theory of heat, and the discovery of its exact mechanical equivalent, has enabled clear and definite explanations to be given to certain phenomena which before could only be recorded as facts; for example, the changes of temperature in the expansion and compression of gases. It was known that the specific heat of air, when the volume remained constant but the pressure was allowed to vary, was ·169, whereas the specific heat of the same air, when the volume was allowed to increase and the pressure to remain constant, was ·238, that is to say, greater in the proportion of 1 to 1·408. Air under pressure, when allowed to escape into the atmosphere, is greatly chilled, whereas air might be expanded under the bell glass of an air-pump without any loss of sensible heat. The explanation is now easy. In warming air at constant volume there is no external work done, there is no enlargement of the space con-containing the perfectly elastic molecules, their energy of motion is increased, the velocity with which they strike the sides of the containing vessel and collide against each other is increased; but as the sides do not move, their energy performs no external work, but is rendered sensible in the potential form of pressure. A rise of 1° is obtained by the communication to each pound of air of ·169 heat units. But when the sides of the containing vessel are moveable, and the contained gas is heated, the molecules striking the sides with increased energy cause them to yield

against the pressure of the atmosphere or other resistance, motion takes place, and work is done proportional to the pressure multiplied by the space passed through. The heat necessary to raise the sensible temperature of the gas 1° is increased by the equivalent of work done, and hence it is found that 1 lb. of air under such circumstances requires ·238 units of heat to raise its temperature 1°. We can work this out a little more in detail. A pound of air at the freezing point, or 492° absolute, measures 12,387 cubic feet. If we double the temperature without altering the volume, we shall raise the absolute pressure to two atmospheres, or 29·4 lbs. per square inch, and consume in so doing 1 lb. × 492° × ·169 = 83·150 heat units. If, however, we allow the air to expand while being heated, causing it to displace or lift the atmosphere, keeping the pressure constant to 14·7 lbs. per square inch, we shall double the volume and displace 12·387 cubic feet fair, and the work done will be 12·387 cubic feet × 2,117 lbs. = 26,222 foot-pounds· Dividing this by Joule's equivalent, we get 33·966 units of heat absorbed in performing the work, and, therefore, 1 lb. of air will require 83·15*u* + 33·966*u* = 117·116*u* to double its temperature at constant pressure, and the ratio of the two operations will be—

$$\frac{117{\cdot}116u}{83{\cdot}15u} = 1{\cdot}408.$$

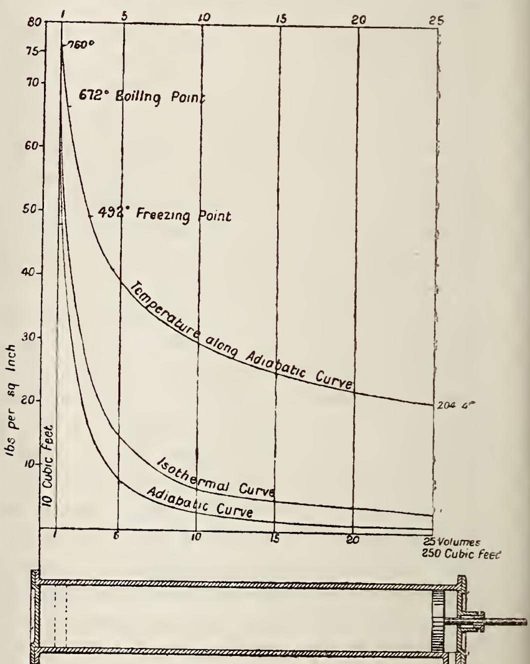
This ratio of the specific heat of air at constant volume to that at constant pressure is, therefore, 1 to 1·408, and is generally represented by the Greek letter γ, the value of which depends upon the nature of the gas. If air at a given pressure and temperature is allowed to expand during work, and if matters are so arranged that heat can neither escape or be communicated, the pressure will not follow the law of Boyle, but will be defined by what has been termed an adiabatic curve, or a curve which represents the pressure corresponding to any alteration of volume, on the supposition that heat neither enters nor leaves the gas, and that external work is being done as the gas expands.

The equation to the isothermal curve, as already stated, is $p_1 = p\frac{v}{v_1}$ while the equation to the adiabatic curve for air is $p_1 = p\left(\frac{v}{v_1}\right)^{1\cdot408}$ that is to say, the pressure varies not inversely as the ratio of the volume, but as that ratio raised to the power of γ which we have seen is, for air, 1·408.

In the diagram I have drawn the isothermal and the adiabatic lines for 10 cubic feet of air at 75 lbs. pressure and 300° temperature, that is, 760° absolute, expanded to 250 cubic feet. You see that the two curves approach each other, and the base line; but for the reason already stated they can never touch it.

The volume of a gas varies as its absolute temperature $v_1 = \frac{v\ t_1}{t}$ and conversely the temperature varies as the volume $t_1 = t\frac{v_1}{v}$ but in the adiabatic curve, the temperature falls as the gas expands, doing work, and may be calculated by the equation $t_1 = t\left(\frac{v}{v_1}\right)^{\gamma-1}$ or $= t\left(\frac{v}{v_1}\right)^{\cdot408}$ that is, not inversely as the

FIG 18.



volume, but as that ratio raised to the power of $\gamma - 1$ or ·408, which is not far from the square root. On the diagram I have also traced the curve of temperature which the air will assume while expanding along the adiabatic curve. You will see that the curve of temperatures also tends to meet the two pressure curves. The areas of the spaces in the diagram between the curves and the base line represent the external work done during expansion.

For the isothermal curve, which is a hyperbola, the equation for the work done is—

$$W = pv \log.^{E} \frac{v_1}{v}.$$

The work done along the adiabatic curve is found by the equation—

$$W = \frac{p_1 v_1}{\gamma - 1}\left\{1 - \left(\frac{v_1}{v}\right)^{\gamma - 1}\right\}$$

$$W = \frac{p_1 v_1}{\cdot 408}\left\{1 - \left(\frac{v_1}{v}\right)^{\cdot 408}\right\}$$

As I believe that the important principles I have explained will impress themselves much better on your minds if I give you a numerical example, I have calculated the work done by the two conditions in the diagram. First expanding along the adiabatic line, so that the air pressure at the end of the stroke will be a little above that of the atmosphere, in order that it may be exhausted into it, we find that an expansion of three times brings the pressure down to 15·97 lbs., or 1·27 lbs. above the atmosphere, and the temperature will fall from 760° to 485·4°, that is, 7° below the freezing point, a fall of 274·6°. The weight of 10 cubic feet of air at 760°, and 75 lbs. pressure is 2·6638 lbs.

The work done

$$= \frac{75 \text{ lbs.} \times 144 \text{ c. in.} \times 10 \text{ c. ft.}}{\cdot 408}\left\{1 - \left(\tfrac{1}{3}\right)^{\cdot 408}\right\}$$

$= 95638$ foot-pounds.

The number of units of heat which have disappeared is $= 2{\cdot}6638$ lbs. $\times\ 274{\cdot}6° \times {\cdot}169 = 123{\cdot}6$ units, and the corresponding foot pounds $= 123{\cdot}6 \times 772 = 95{,}436$ foot-pounds, very nearly the same as determined by the previous method. This shows that the work done depends upon the fall of temperature only, and not in any manner on the pressure or volume of the substance, or its nature. In calculating the work from the change of temperature, the weight of the air in action must be ascertained, and to do that we must reduce it to the standard temperature of 492°, and pressure of 14·7 lbs., at which a cubic foot weighs 0·080728 lbs.

The calculation then stands thus—

$$W = \frac{10 \text{ c. ft.} \times 75 \text{ lbs.}}{14{\cdot}7} \times \frac{492°}{760°} \times 0{,}080728 \text{ lbs.} \times$$

$$274{\cdot}6° \times {\cdot}169 \times 772 = 95436 \text{ foot-pounds.}$$

You will notice in this sum that 274·6° is the difference between the higher and the lower temperatures between which the air is working, and 760° is the higher temperature of the air, so that the work done is in proportion to the difference of temperature divided by the higher temperature; or if T be the higher and t the lower temperature, then the available work is proportional $\frac{T - t}{T}$, which is a fundamental principle of the conversion of heat into work.

Counting from absolute zero, the total heat of 10 cubic feet of air weighing 2·6638 lbs. is $2{\cdot}6638 \times 760 \times {\cdot}169 = 342{\cdot}14$ units; of these we have utilised $2{\cdot}6638 \times 274{\cdot}6 \times {\cdot}162 = 123{\cdot}62$, therefore the ratio is $\frac{123{\cdot}62}{342{\cdot}14} = {\cdot}36$; only 36 per cent. of the total heat can be realised, and this is the ratio of the difference of temperature to the highest temperature, or 274·6° : 760°.

But suppose that, during expansion, additional heat were supplied to the air, so that its temperature should not change, how much heat should be added? The work done along the isothermal line would be $= 75$ lbs. $\times$ 10 c. ft. $\times$ 144 c. in. $\times \log.^{E} \left(\frac{3}{1}\right) = 118{,}650$ foot-pounds, corresponding to $\frac{118{,}650}{772} = 153{\cdot}7$ units. The additional work done, over that due to the adiabatic curve, $118{,}650 - 95{,}638 = 23{,}012$ foot-pounds $= 29{\cdot}8$ units; adding this to the units of heat converted into work along the adiabatic curve, we have $123{\cdot}62 + 29{\cdot}8 = 153{\cdot}4$ units, very nearly the amount derived from the other mode of reasoning. Hence we see that the addition of heat, as the substance works, is incompetent to do any more work than if it were originally imparted. It has had the effect, indeed, of enabling the ten cubic feet of gas to do more work in the same apparatus, but it has not effected any economy in heat. Let us pursue this important matter a little farther. You see that the expansion to three times along the isothermal leaves the air at 25 lbs. pressure, or 10·3 lbs. above the atmosphere, instead of 1·27 lbs. as in the case of the adiabatic; hence we have 9·03 of potential energy, which may be utilised by extending the stroke to 4·7 volumes, and an amount of work = 166,978 foot-pounds, corresponding to 216·3 units will be realised, but still no more than is due to the heat imparted to the gas.

In the case of a gas, such as steam, near its point of condensation, the adiabatic curve cannot be followed, because the moment the temperature falls to the point where, at the particular pressure, condensation begins, the nature of the agent changes, and a portion of it becomes liquid. The theoretical curve of pressure would therefore be between the adiabatic and isothermal lines, because a very

slight fall of pressure sets free a great deal of heat. For example, a change caused by cooling from 31 to 30 lbs. pressure in a body of steam weighing 3·27 lbs. would condense $\frac{1}{10}$ of a pound, and the heat liberated would be competent to raise the temperature of the steam 79°. It is impossible, mathematically, to define the curve of pressure that steam would actually register, but this need inspire no regret, because the conditions are such as never can occur in practice. It is plain, however, that whatsoever changes take place in the relative proportions of liquid and vapour, they can have no effect on the fundamental proposition that the quantity of work done by steam depends only upon its fall of temperature. Steam at 150 lbs. absolute pressure and 818° temperature may be worked down to 2 lbs. pressure and 586° temperature, but the per-centage of duty to be obtained from the total heat of such steam can never exceed $\frac{818 - 586}{818} = \cdot 28$, or, in other words, 72 per cent. of the power cannot be realised.

In all the above investigations I have been dealing with an ideal state of things. All heat engines work in cycles, the vessels containing the working substances are more or less pervious to and retentive of heat, hence, as in the case of the cylinders of hot air or steam-engines, they are colder than the working substance when it enters and hotter when it leaves, so that the pressure curves are generally between the isothermal and adiabatic. Steam-jackets have been introduced in order to keep up a temperature and cause the working substance to expand along the isothermal line. What I have already said on this subject shows that there is no theoretical gain in steam-jackets; they can produce no effect whatever upon the fact that every foot-pound of work is represented by a corresponding absorption of heat, but a steam-jacket makes the curve of pressure follow more nearly the isothermal line, and so enables the same engine to do a larger quantity of work, without sensibly increasing friction and other resistances, and to use a rate of expansion which necessitates a greater range of temperature in the working substance, and hence economy.

A practical application of the laws relating to the compression and expansion of gases is found in Colonel Moncreiff's hydropneumatic carriages for disappearing guns. In Colonel Moncreiff's system the gun fires over a parapet, and recoils backwards and downwards into an emplacement, where the gun and its detachment are completely protected by the earthwork of the battery, and where loading can go on in safety. The energy of recoil and work due to the falling gun are transferred to a ram working into a hydraulic cylinder, the water in which is in communication with an air vessel by means of a passage fitted with a self-acting valve, opening from the cylinder into the air-vessel. The air vessel is about $2\frac{1}{2}$ times the volume of the ram, and is charged with air at such a pressure that the work of further compressing it shall be equal to the work due to the discharge and falling gun. Recoil taking place in but the fraction of a second, heat has no time to escape, the air pressure increases therefore in proportion to the ordinates of an adiabatic curve. While the gun is being loaded, the air cools, and assumes the pressure due to the temperature of the surrounding atmosphere, and when the gun is raised briskly into the firing position, which is done by opening a communication between the water in the bottom of the air vessel and the hydraulic cylinder by means of a cock, the air expands, also nearly according to the ordinates of an adiabatic curve. After the gun has been up two or three minutes, the pressure of the air rises, and becomes stationary at that due to the temperature of the atmosphere. If the gun be raised or hauled down slowly, the pressures vary according to the isothermal curve. The energy of the discharge has been converted into heat which has been slowly dissipated in the atmosphere, and a portion of that heat has been requisitioned again and converted into the work done in lifting the gun.

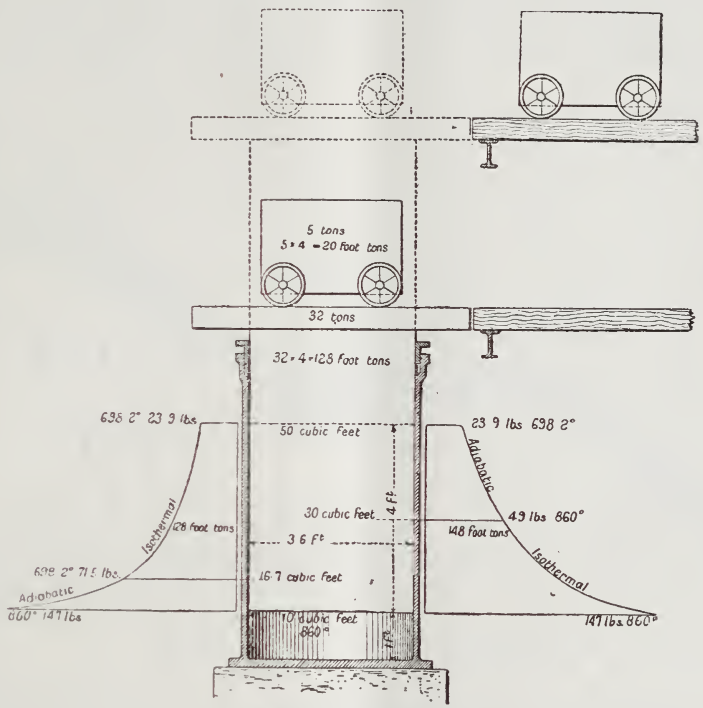
But you may justly object that I have, up to the present, merely laid before you a particular case of conversion of heat into work, and that no general theory can safely be based on an isolated example. Your objection would be quite just, and I now proceed to lay before you the great doctrine first propounded in 1824 by Sadi Carnot, but only recently fully appreciated and brought into notice.

Before you can determine the efficiency of any machine, you must be sure that the machine is so adjusted as to be producing as much work as it is capable of doing. To ascertain whether a machine is so adjusted, Carnot hit upon the idea of a reversible engine. He argued that, if a heat engine took in a certain quantity of heat, and gave out a definite amount of work, that if the engine were perfect it could be reversed, and by application of the same work would give back

to its source the exact quantity of heat that had at first produced the work. For supposing A were an engine as above described, and yet that there was another engine, B, more perfect, that is to say, capable of producing more work than A from the same quantity of heat. Let the two engines be coupled, and let B drive A in the reverse direction. If B is a superior engine to the perfectly reversible engine A, then B would do more work than A, and as A converts all the work into heat, it follows that B would return more heat to the source through A than it took from the source, there would therefore be a continued accumulation of heat due to the working of the coupled engines, which is contrary to experience and to the law that neither matter nor energy can be created or destroyed, so that an engine which is completely reversible, *is* a perfect engine, and extracts all the work that can be got out of the heat imparted to it.

We will now take a particular case of an engine making a complete cycle, that is, making one double stroke during which useful external work is done, and the engine returns at the end of the cycle

Fig. 19.



Carnot's Engine.

to exactly the same state as it was at the beginning. We are now engaged in considering a purely ideal engine, one that can never be constructed, because we have no materials possessing the properties of perfect transparency and perfect opaqueness to heat, which I shall assume, so I must beg you to accept, merely as conceivable, the alterations in the nature of the material of the cylinder which I shall indicate. It is usual to express the changes which take place by means of algebraic symbols, but I have preferred to work out a case in figures, because I think the reality of the doctrine will impress itself more clearly on your minds, and will at the same time serve as a practical application of the theories we have already discussed.

On the diagram is represented a vertical cylinder about 3·6 ft. in diameter, or having a cross section of 10 sq. ft.; the length is 5 ft. Sliding air-tight in the cylinder is a ram, loaded on its upper end so that the permanent weight of the ram, including the pressure of the atmosphere, is equal to about 32 tons. A movable load of 5 tons, which the apparatus is constructed to raise to a height of 4 ft., is fitted with wheels, so that it can be rolled off the head of the ram when raised to the proper

height. The ram is arranged so that it cannot fall lower than within one foot of the bottom of the cylinder, leaving there 10 cubic feet of space. It is immaterial what gas we employ for working this machine; we will, therefore, use air, as being most conveniently obtainable. We compress the air, and heat it by some means till we obtain a pressure of 10 atmospheres, or 147 lbs. per square inch, and a temperature of 400° Fahr., or 860° absolute. The material of which the cylinder and ram are made does not allow any heat to escape. The upward pressure on the bottom of the ram is nearly 95 tons, so that if we release the ram, it will rise with considerable velocity, on account of the accelerating force being 95 tons acting on a weight of 37 tons only.

We arrange matters so that while the first half of the stroke, or 2 feet, is being accomplished, the air is kept heated by some means, so that it should expand and press upon the ram according to the ordinates of an isothermal curve for 860°. On each side of the cylinder I have drawn a diagram, in which the horizontal ordinates of the curves show the pressures at any point; the curves on the right hand side give the pressures during the up stroke. If we continued heating the air farther, we should have an excess of power, so, at half stroke, when the pressure has fallen to 49 lbs., the supply of heat is cut off, and the air will continue to expand, falling in temperature and in pressure according to the ordinates of an adiabatic curve, till at the end of the stroke the pressure has fallen to 23·9 lbs., and the temperature to 698·2°, and the gas occupies 50 cubic feet. The terminal pressure on the ram only gives an upward push of 15·3 tons, so that the stroke is completed by virtue of the momentum imparted at the beginning, and the ram must be held up at the finish of the stroke if it is desired to stop the machine. The work done is represented by the area of the diagram on the right hand side, and is equal to about 37 tons lifted 4 feet = 148 foot-tons. We now roll off the load of 5 tons which it has been our object to lift, and we must get the ram, now reduced to 32 tons weight, back into its original position ready for another stroke; this would represent work = 128 foot-tons, and must be balanced by the resistance of the gas to compression from 50 cubic feet to 10 cubic feet. The upward pressure on the ram, I have already said, is reduced to 15·3 tons, so that an accelerating force of nearly 17 tons is available to start the downward motion.

If we arrange so as to prevent all escape of heat due to the work of compression, the pressures will rise according to the ordinates of an adiabatic curve, and the work done will be about 175 foot-tons, which is 47 foot-tons more than the weight of the ram is competent to perform, and therefore it would not reach the bottom of its stroke. If we arrange so as to prevent the temperature rising above 698·2°, the initial temperature of the return stroke, the pressures will rise according to the isothermal curve of 628·2°, and the work done will be 123 foot-tons, which will be too little to absorb the work of the falling ram; therefore we must stop the escape of heat after a time, and allow the plunger to complete its down stroke so that the pressures shall rise as ordinates of an adiabatic curve. We must commence retaining the heat at such a point that the pressure will rise to 147 lbs., and the temperature to 860°, at the end of the stroke, and leave the air in exactly the same condition as it existed at the commencement of the up stroke. The point at which the exit of heat is to be stopped is easily calculated by applying the formula—

$$t_1 = t\left(\frac{v}{v_1}\right)^{\cdot 408}$$

$$\text{Therefore } v = \frac{v}{\left(\frac{t_1}{t}\right)^{2.45}}$$

We know $v = 10$ c. ft., $t = 860°$, $t_1 = 682·2°$ and therefore v_1 16·66 cubic feet; therefore compression along the isothermal line, as represented on the left side of the diagram, will go on for 3·33 feet, and along the adiabatic for ·67 feet.

When the ram reaches the position from which it started, we have the air in exactly the same condition as to quantity, temperature, and pressure, as it was at the beginning of the up stroke, there is no change in the mechanism; it is plain, therefore, that the useful work done of raising 5 tons 4 feet could not be due to the air, for no change has taken place in it. The changes which have taken place are:—1st, we have added heat during the first half of the up stroke, and secondly, have suffered heat to escape during 3·33 feet of the down stroke.

How much heat has been communicated to the air and again abstracted from it? It is clear that the air, in expanding to half the stroke without change of temperature, must have taken in the quantity of heat equivalent to the work done. We measure or calculate the

area of the figure representing the work done and find it to be 232,500 foot-pounds. Dividing by 772, Joule's equivalent, we obtain that 301·2 units of heat must have been communicated to the air.

Next, because the temperature of the air did not rise during the first 3·33 feet of compression in the down stroke, it is clear that the amount of heat due to the work done of 32 tons falling 3·33 feet must have been taken off. Measuring the figure bounded by the isothermal curve, we find it to have an area of 188,880 foot-pounds. Dividing by 772 again, we get 244·7 units. We, therefore, added 301·2 units of heat and abstracted 244·7 units, what has become of the difference, 56·5 units? Multiplying by 772, we get 43,618 foot-pounds, which is very nearly the work of lifting the load of 5 tons which we have raised to a height of 4 feet, hence 56·6 units of heat have been converted into the potential energy of 5 tons with respect to a fall of 4 feet. Next observe that in this perfect engine we have expended 301·2 units of heat to convert 56·5 units into useful work; the proportion is only 19 per cent. The temperature of the air fell from 890° to 608·2°, a difference of 161·8°, the ratio of this difference to the absolute temperature of the air at the commencement is also 19 per cent., and so we establish this fundamental law of the conversion of heat into useful work, that the proportion of heat imparted to the working substance which can be converted into useful work is the proportion which the fall of temperature bears to the original absolute temperature. Let H = heat imparted to the working substance, and T and t the absolute temperatures at the beginning and end of the operation, then useful work $= H \frac{T-t}{T}$.

Fig. 20.

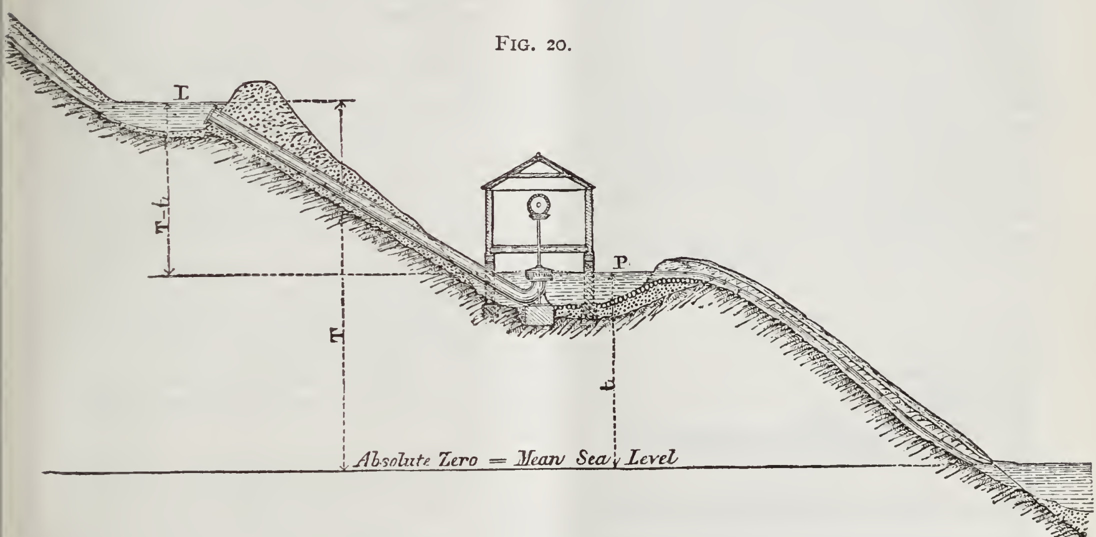


Illustration of Carnot's Doctrine, 1824.

In addition, you should note that the nature of the working substance, its absolute temperature at starting, the mode in which it is heated and cooled, and the mechanical arrangement by which the conversion is affected, have none of them anything to do with the result.

It is true that in practice we cannot attain to the duty done by our ideal engine, but we can apply the law I have just laid before you, and determine in practice what is the limit which we can hope to reach. In some cases, such as the generation of steam, where no machinery is interposed, we attain very nearly the theoretical duty.

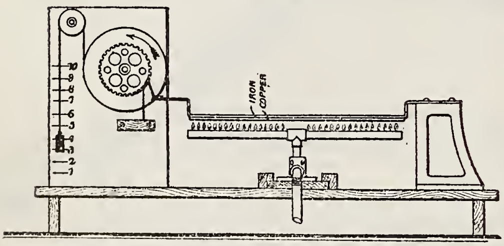
Carnot illustrated his theory by referring to the arrangement for utilising a fall of water. Suppose a reservoir on a hill side, from which a pipe is led into a turbine part of the way down the hill, and from thence the tail race is carried into the sea. The mean sea level is the lowest point to which water can fall, and may be compared to the absolute zero of temperature. Let the height of the water in the reservoir above the sea be T, the height of the water in the tail race at the mill be t, and the weight of water falling per minute W. In the reservoir, the potential energy of the water per

minute, with reference to the sea level, is W T, and that is also the maximum kinetic energy which it is capable of being endowed with, so that a perfect disposition could only be attained by placing the mill at the sea level. The potential energy of the water in the pool at the mill is $W\,t$, hence the energy utilised is $W\,T - W\,t = W\,(T - t)$, that is the weight of water multiplied by the nett fall, and the proportion which this bears to the absolute maximum energy is $\frac{WT - Wt}{WT} = \left(\frac{T-t}{T}\right)$ or in other words, the proportion which the fall actually utilised bears to the maximum possible fall. Carnot's theory may be reasoned out in a common sense way thus:—The quantity of heat, or of energy, given out by a gas as it cools, is in direct proportion to the change of temperature. It is obvious that the only way to get all the energy out of a gas is to cool it down to absolute zero, and therefore, if you only cool it, say, to 1-6th of the way to zero, you can only get 1-6th of the possible work.

I have said that it is immaterial what the working substance may be. I have made use of air and gases, but I have constructed a true heat engine of metal.

You see before you a compound bar com-

FIG. 21.



posed of a strip of copper rivetted underneath a strip of iron. One end of the bar is rigidly fixed to a stand, the other end is free, and actuates a ratchet wheel by means of a pawl. A second fixed pawl prevents the wheel running back, and to the wheel is fastened a drum, round which is wound a cord, by means of which I propose to raise this weight.

I heat the compound bar by means of gas jets—the copper expands more than the iron —the bar consequently curls up, and the ratchet, at its end, carries round the wheel, and so lifts the weight. My bar is now in the same condition as the ideal engine when it had raised the load of five tons; I must get it back again to its original position, so as to complete the cycle and leave the engine ready for the next stroke. I can only do this by cooling the bar. I immerse it into a tank containing wetted waste, which I raise up to it. You see it returns instantly to its original condition, and is ready for another stroke. By repeating the operation I am enabled to lift the weight as high as I please. In this case, also, it would be found that the amount of heat communicated to the bar is more than that abstracted from it by the amount converted into the mechanical work of raising the weight.

According to Newton's third law of motion, to every action there is an equal and opposite reaction, and as we believe, according to Sir Humphry Davy, that the molecular motion which we call heat obeys the ordinary laws of motion, so we conclude that the ideal heat engine is perfectly reversible. The action of the heated air had for its reaction the raising of the load and the ram, therefore if the falling of the load and ram were the action, the compression of the air and the development of a certain amount of heat would be the reaction. Again, the action of the falling ram finds its equivalent in the reaction of the compressed air and the liberated heat, consequently when the air is permitted to expand, and is suitably warmed, the reaction will be the return of the ram to its original position ready to receive another load. The balance of this reverse operation will be the accumulation of an amount of heat represented by the work done by five tons falling four feet.

You will observe that a necessary condition of action is a fall of temperature. The ideal engine finished its work, which was all done in the *up* stroke at a lower temperature than it began, and in the heated bar; though the reverse apparently took place, it was only because the normal condition of the bar is to be cold. Had I begun with the bar like the air in its heated state, I could have done the work by cooling it.

I am now enabled to enunciate the second law of thermodynamics, which is—"It is impossible to transform any part of the heat of a body into mechanical work, except by allowing heat to pass from that body into another at a lower temperature."

I fear that I have wearied you by the strain which the explanation of this part of my subject has imposed, but it is of the utmost importance, as you will see later on. Had the principles of Carnot been earlier recognised and known, a vast saving of fruitless expen-

diture in toil, money, and hope deferred would have been saved to unhappy inventors, who, through ignorance, have been lured on to attempt results in the working of heat engines, which are just as much beyond our reach as the transmutation of metals or perpetual motion.

SEVENTEENTH ORDINARY MEETING.

Wednesday, April 15th, 1885; Sir ROBERT RAWLINSON, C.B., Vice-President, in the chair.

The following candidates were proposed for election as members of the Society:—

Clere, Frederick de Jersey, Wanganui, New Zealand.
Dawson, William, Chingford-hall, Leyton, Essex.
Doxsey, Rev. Isaac, 186, The Grove, Camberwell, S.E.
Fulton, Henry B., 293, Vauxhall-bridge-road, S.W.
Pass, Alfred C., Rushmere-house, Durdham-down, Bristol.
Peyton, Ernest Phelps, Chemical Works, Lister-street, Birmingham.
Polglase, Francis James Wicks, Tyne Vale Chemical Works, Forth-bank, Newcastle-on-Tyne.
Proctor, John, 5, St. George's-ter., Queen's-gate, S.W.
Stern, Edward D., 11, Prince's-gate, S.W.
Whitehead, Smith Taylor, 21, Upper Phillimore-gardens, W.
Wood, Thomas, 3, Royal-crescent, Notting-hill, W.

The following candidates were balloted for and duly elected members of the Society:—

Ellington, Edward Bayzand, Palace-chambers, Bridge-street, S.W.
Fosbery, William Thomas Exham, The Castle-park, Warwick.
Vaughan, J. I., Woodleigh, East Dulwich-grove, S.E.
Watson, Charles, 5, Paradise-row, Stockton-on-Tees.

Papers were read by Dr. Hawksley and Dr. Richardson, F.R.S.

I.—PROPOSAL FOR THE ABOLITION OF WATER-CARRIAGE IN THE REMOVAL OF EFFETE ORGANIC MATTER FROM TOWNS.

By THOS. HAWKSLEY, M.D.Lond., M.R.C.P., &c.

There is no greater or more serious anomaly to be found in this nineteenth century than in the fact that, while science has experienced a development so prodigious as to seem like noonday sunshine in comparison of the dim midnight lights and shadows of all past ages, multiplying a thousandfold the resources, powers, and conveniences of mankind, yet that in the midst of this advance, one requirement, which of all others is most essential to the life, well-being, and prosperity of the race, instead of being on a better basis than in the times of our forefathers, is placed on one much worse. It has absolutely been erected, by a false and erroneous application of what science has been brought to bear upon it, into an institution most vile and abominable in its manifestations, and magnifying in every way the evils due to mismanagement of the requirement referred to—that, namely, of the removal of the effete organic matter of communities, and its consignment to the soil, which alone possesses the appropriate conditions for its reception and utilisation.

Time will not allow me to sketch the history of this great sanitary and social evil, nor to exhibit the enormous losses it entails on the country in lives, in health, in wages due to want of health, and in starvation of the soil, whereby the cost of the first necessaries of life is much enhanced; in addition to which might be computed the intolerable burden of a polluted atmosphere; water everywhere made filthy and poisonous; with the crowning achievement of all the outlay and subsequent rating required to make and maintain the great and unnecessary mechanism by which public injury is developed and perpetuated. All this we must pass over, referring only to a little essay I wrote in 1867,* in which some attempt at an estimate of these evils was made. I must very briefly refer to the last Report of the Royal Commission on Metropolitan Sewage, as affording the most recent evidence of consummated evil on our great water highway, the Thames. Among other signs of this, the Commissioners tell us that fish have disappeared from the river for a distance of fifteen miles below the outfalls, and for a considerable distance above them. At Woolwich, in July last, the Commissioners, speaking from their personal observation, found "the water very black, and with a powerful smell of sewage. This state was worse at Blackwall." "The sewage was distinctly seen." "At Barking the smell was horrible." "At Erith the smell was strong, sewage clearly visible." "At Ordnance Wharf the smell was very bad, and the smell strong in-shore." "At Greenwich Pier the water very black, and the smell excessively strong." One Commissioner describes the river at Woolwich for its whole width as "black putrid sewage, the stench intolerable." Again, it is described as in appearance, "crude, unmixed, and unmitigated sewage,"

* "Matter: Its Ministry to Life in Health and Disease." John Churchill and Sons, New Burlington-street.

and as "a condition of things which we must denounce as a disgrace to the metropolis and to civilisation." Again, "the sewage water manifestly reached London-bridge. There were $11\frac{1}{4}$ per cent. of sea water in it, and twice as much impurity in it as Mr. Dibdin ever found in the river off the outfalls." "The odour was very nasty, and clung to one's clothes and beard for hours." Three of the five Commissioners, together with their clerk, were attacked with severe diarrhœa the night following these observations, and the crew of the steamboat employed also suffered.

As to the land evils, I would also quote a few words from a paper communicated by my friend, Dr. B. W. Richardson, to this Society on March 28th, 1884, on "Vital Steps in Sanitary Progress." At page 455 of the Society's *Journal*, he says:—

"At the instance of Mr. Edwin Chadwick, whose name as a sanitarian is a name of the century—we did, some time ago, commence an inquiry here bearing upon the vital point now under consideration. We opened—or rather re-opened—the sewage question, and we discerned all at once, although our inquiries were confined to limited areas of London, so much evil, that we rather abruptly closed the evil up again, as if we were frightened at it. It is all in vain, for sewage, like murder, will out, and we must once more proceed. What we did discover was in truth so serious that the wonder we labour under is how London can be so healthy as it is. We found that London is still honeycombed with what are in fact, if not in name, cesspools—a fact we all recognise by the second measures we take to meet the primary blunder."

And then, referring to one of these second measures, namely, ventilating shafts, he says:—

"My contention is, that the decomposition which gives origin to the gases that are let out by thousands upon thousands of channels, by tubes from houses, by soil-pipes within houses, by accidental openings and pores in all directions, by great outlets of sewers from accumulations of sewage, ought never to have been generated at all, but that the sewage, removed clean away, without even having decomposed, either above or below the living place, should never infest the place, nor have any destination except the land which is calling for it, and which dies if its demands be not naturally supplied."

Happily, there is no evidence that a water-carriage is essential to the removal of excrementitious matters from towns, and the good old belief in a providential adaptation of means to ends finds in this case a grand illustration, grand not only for its perfection, but for its vastness, the dark robe of friable matter which more or less covers the globe, and which in every climate possesses a wonderful degree of uniformity in appearance and qualities—earth—the bountiful mother of all vegetable life—has received of late years the successful investigations of many skilled observers. Prof. Way* has shown that in the clayey soils especially, which, produced by the disintegration of the granite rocks, consist of felspar and albite, the former composed of a double silicate of alumina and potash, and the latter of the double silicate of alumina, lime, and soda; that when these are exposed to the contact of dead organic matter they rend apart its chemical atoms, and immediately reform them, the ammonia being greedily seized by the silicate of alumina, the magnesia phosphate in like manner, and in next degree the potash, lime, and soda, in proportion to their comparative absence in the original soil. Thus the most offensive organic substance is quickly transformed from an unstable and putrefying condition into that of stability, and of the most perfect fitness for the food of plants.

More recently, Darwin † has told us the wonderful story which so well accounts for the physical and some of the chemical and physiological qualities of earth. He has exalted the character and good service of the despised earthworm, and shown us how important is its ministry to our life and well being. He has explained that these creatures literally swallow the earth in large quantities, together with broken leaves and twigs, and bringing up the earthy elements from considerable depths, discharge the whole as castings upon the surface. In this way it is calculated that in the course of ten years the surface of the soil may be raised for an inch and a-half. Quoting from Hensen, he says that as many as 53,767 worms to the acre have been found; and Darwin, himself, has found the individual castings to weigh from 4·34 ozs. to 6·7 ozs. The largest are found on poor land, because he supposes that for the same amount of nourishment the worm has to swallow so much more of the poor earth; the weight of earth thus renewed in one year, has been found by Dr. King, near Nice, to be equal to 14·58 tons to the acre. On the chalk, Darwin found it 18·12 tons to the acre; on Leith-hill Common, 16·1

* "On the Power of Soils to Absorb," &c. Journal of the Royal Agricultural Society of England, vol. xi, part 1.

† "Formation of Vegetable Mould through the action of Worms." By Charles Darwin, F.R.S. 1881.

tons to the acre, per annum each. He thinks that by the process the amount of soil is actually increased, though only to a small degree, but that the chief good effected is in sifting the finer from the coarser particles, combining them with vegetable *debris*, and in saturating them with intestinal secretions.

These brief references to the scientific history of earth will be sufficient to remind my audience of its remarkable and unique fitness for being the most suitable and the natural carrier of effete organic matter, and we will now proceed to show that its use is as easy and practicable for that purpose in a dense community as in scattered dwellings, and not less agreeable and convenient in use than water.

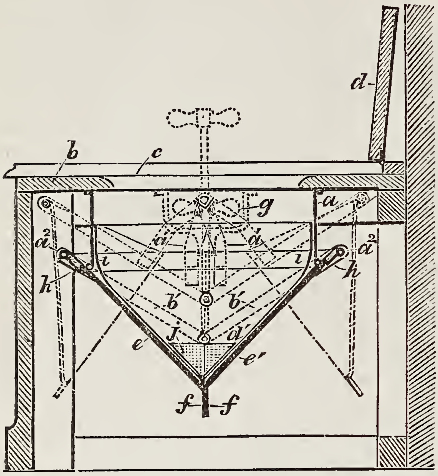
The late Rev. Henry Moule deserves great credit for the ingenuity, and especially for the public spirit and indefatigable labours which he brought to bear upon this subject. The closet he invented is in great demand. He did not, however, appear to see his way to the diaplacement of water by earth in the large towns, which with me has always been *the* object, and I contended for it in two communications, one to the Social Science Association at their annual congress, held at Manchester, in 1867; and the other at the Leamington Congress of the same year, wherein I proposed a scheme for the purpose; afterwards published in the essay to which I have already made reference. Since then, the pressure of professional pursuits, together with the impediment of broken health, have prevented me pursuing the subject actively, though the constantly recurring examples of loss and damage due to the water-carriage system, have kept my mind constantly exercised thereon. I may, perhaps, be excused if I give a recent example. A few months back, a distinguished military officer, between fifty and sixty years of age, was sent in an invalid cariage, from his house at Kensington, to Brighton, by the eminent physicians who were attending him, as a desperate last resource to save his life; he was suffering from the low fever of blood poisoning, which also threatened abscess of the liver. I saw him on his arrival, and only wondered that he had borne the journey without sinking. However he made an extraordinarily rapid recovery. Mr. Jowers of Brighton assisted me in the conduct of the case. Some time after his recovery, the patient called upon me in town, and said—"We found out the cause of the fever; the house I lived in had for some time been exuding bad odours; we had the whole drainage works dug up, and found the soil pipe disjointed from the pressure of accumulation within, and the basement one horrible slough of putrefying matter."

It is probable that this example represents a state of things which extensively prevails in underground London, and the prevention of which, under the water-carriage system, we may well despair of, considering the inherent difficulties the system has perpetually to contend with from natural law, which rebels against tenacious solids flowing like water through tubes; and against the requisition which so often prevails of flowing up an ascent instead of down; together with the difficulty of coercing chemical law, which refuses to allow unstable chemical compounds to remain undecomposed while the process of conveying them from the town to the sea is conducted. These invasions of natural law must lead to constant failure, no matter how much engineering skill is brought to prevent it.

Reflecting on the present state of the question, the reason why the water system still finds supporters, and the dry-earth method had made so little progress, and after making allowance for the *vis inertiæ* produced by habit, also the familiar experience of every one's business being no one's, also the power of vested interests, also the power of prejudice uncorrected by fact and experiment, yet it seemed probable that another great impediment was to be found in the fact that so many people spoke ill of the earth-closets, from a belief that their use was often attended by bad odours, want of cleanliness, and the inconvenience of supplying them with the suitable earth. The first step, therefore, in again advocating their use, appeared to be that of improving the necessary apparatus, in the hope of supplying all the advantages of the water system, as regards purity, promptitude, and convenience in the house, but without any of the evils inevitable to the same. This endeavour I now submit to the judgment of the Society. It consists of three parts:—(1.) The closet. (2.) A paper liner charged with dry earth. (3.) The conduit leading to the tank, which, placed in the position, back or front of the house, found to be most convenient, receives the combination of earth and dejecta from the closets, and from which, like the dust of the house, it is removed at regular and appropriate intervals.

Description of Apparatus.—The closet is simple, strong, and very inexpensive. The metal part admits of being affixed to the woodwork of the ordinary w.c., in which case nearly half of the whole expense is saved. It

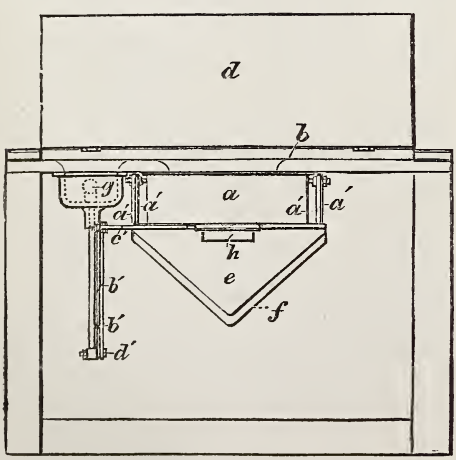
consists of an upper ring of galvanised iron plate, with a conical basin, divided down the middle line into equal halves of a somewhat



SIDE VIEW OF CLOSET.

a. The metallic ring of upper part of basin. *a′* or *a2*. The suspensary levers of the two halves of lower basin. *b*. The seat. *b′*. The levers by which the handle opens the lower basin. *c*. The opening in the seat. *c′*. Rod connecting the hinged part of lower basin. *d*. Top or lid of closet. *d′*. The paper liner to be put into basin whenever used, containing in its apex, *f′*, the earth. *e*. Front view of lower basin. *e′*. Side view of lower basin, showing its two halves. *f*. Flanged junction of above. *f′*. The earth in apex of liner. *g*. The handle. *h*. The counterweight which ordinarily keeps the basin closed.

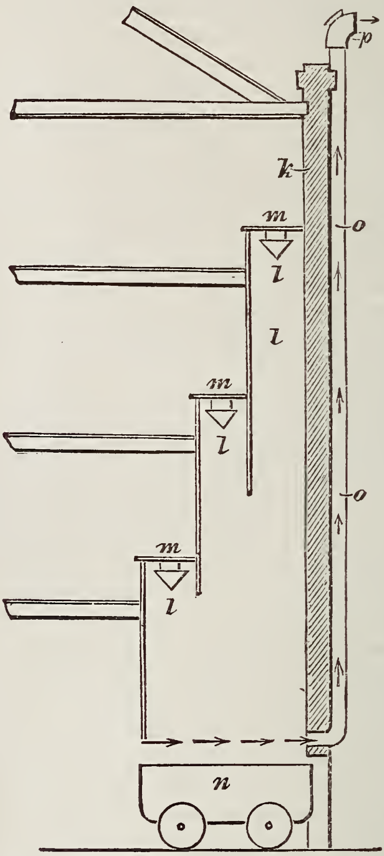
triangular curved shape, the bases hinged to the ring, and so adapted with counterweights and levers that ordinarily the two halves are



FRONT VIEW OF CLOSET.

The letters of reference correspond to the side view.

closed automatically, and, with the ring above, make a complete basin. When used, a paper liner is dropped into this, and after use, the handle being pulled, the liner and its contents drop instantly in the middle line of gravity through the capacious opening formed by the complete and sudden opening of the basin.



PLAN SHOWING THE ARRANGEMENT FOR USING THE CLOSETS ON THE SUCCESSIVE FLOORS OF A HOUSE.

k. The front, or back side wall of the house. *l. l. l.* Divisions of perpendicular shaft, leading from closets to tank. *m. m. m.* Closets or successive floors on stories of the house. *n*. The tank. *o*. Air shaft, and *p*, cowl of same.

2. The paper liner is made very inexpensively, at the rate of 2s. a gross, by the ordinary paper-bag makers, and it serves the threefold purpose of (*a*) preventing any soiling of the basin; (*b*) of supplying the earth in quantity and quality necessary for successful chemical absorption; (*c*) of securing descent in the middle line of gravity, and thereby preventing any soiling of the walls of the conduit.

3. The conduit in structure implies only an enclosed vertical space of the dimensions suitable for conveying the paper liner and its

contents directly to the tank without soiling. The horizontal dimension of 10 square inches, and the length from the floor where the closet is placed to the area where the tank is placed, represents the measurements. For cheapness the conduits may be constructed of thin scantling, or zinc, or galvanised iron plate, or brick cement, or any other substance, and where several are placed side by side, the junction walls may be dispensed with advantageously.

It is a great advantage, in changing the water-closet into an earth-closet, to reserve the waste-pipe discharging into the existing sewers and attach it to a sink for the discharge of slop and bath water, and which may also be used as a urinal. This entirely prevents the temptation to throw any fluids into the earth-closet.

Results of Experiment with the New Apparatus.—A family of five persons, consisting of father, mother, two children, and a nurse, living in an airy, well-lighted house on the first and second floors, present the conditions of this experiment. On the first ascent of the staircase was an old-fashioned water-closet in a small chamber of about six feet square. The water-closet was removed and replaced by the earth-closet. The waste-pipe was adapted to a grated sink sunk into a small wooden seat, made convenient for use as a urinal. The conduit passed through the floor of the little chamber into the back area, and ended in a zinc tank. The whole has been in use between four and five months, and has acted continuously without the slightest failure or objection of any kind, and without any odour either in the closet or its precincts. The contents of the tank have been emptied once a fortnight by a neighbouring gardener, who gladly gives the earth and what little labour and trouble are required, for the value of the material. The latter is for the most part solid, with a small portion pultaceous, and the whole quite inoffensive. Specimens are exhibited. The quantity affords a datum of great importance in reference to the practicability of the method for a large community. The greatest care has been adopted to insure accuracy, by first weighing the tank with the earth put in at the beginning to start with, and before emptying the whole, re-weighing it to find the additional weight, which will be that of the dejections plus the quantity of earth contributed by the liners, which are found to average six for each person per week.

The experiment thus arranged and conducted gives the following results:—Between the 1st of January and the 2nd of April in this year eight observations were made; the four first were weekly, the fifth at the end of a fortnight, the sixth of three weeks, the seventh and eighth each at the end of the fortnight; with the result that while the variations from week to week were within 5 lbs., the average for the thirteen weeks amounted to 22 lbs. per week, and allowing 12 additional pounds of dry earth per week, placed in the tank at the beginning of each trial, it was found that an average of 35 to 40 lbs. per week represented the whole amount to be removed. It was also found that, whether the interval of removal was weekly, fortnightly, or three weeks, in each and every case the contents of the tank were inoffensive, and might be carried through the house or streets without attracting any notice. The average 22 lbs. per week for five persons would represent 4 lbs. 1½ oz. for each, and taking from this the 24 ozs. of earth supplied by the use of six liners in the week, the quantity would equal 2 lbs. 14½ oz. for each person per week of pure excreta.

Referring to the quantities stated in the reports from different localities in which the pail or tub system is in use, and given at the Conference on Health and Sewage, held by this Society on the 3rd and 4th of May, 1877, we find that at Rochdale the amount was 1 lb. 10 oz. per head per week, a little more than half that of Brighton; at Halifax the amount was 7 lbs. per head per week; at Birmingham the amount was 9 lbs., three times that of Brighton.

We also read in the same reports that other things beside excreta were found in the tubs, such as castaway tins, dead animals, &c. It seems probable, therefore, that while the results at Brighton give a much less amount than at Halifax and Birmingham, but nearly double that at Rochdale, yet that, in consequence of the admixture with metal, dead animals, &c., those larger amounts are untrustworthy, and by no means discredit the careful and accurate results of observation at Brighton. On the other hand, it is highly probable that, in families with a larger proportion of adults, the average amount would be considerably higher. The amount of earth employed at Brighton has been purposely used at a minimum, in order to try the question of consistency of mass and inoffensiveness on the least favourable conditions. In framing a scheme for the administration of the dry-earth system, it will be desirable to allow for

more considerable weights of excreta, and for the use of a larger proportion of dry earth than in the minimum quantity employed at Brighton. In the following calculations, therefore, it is supposed that the average weight of the excretions for each person per week may be 15 ozs. per diem, or 6 lbs. 9 ozs. per week, and the whole amount of dry earth employed at the rate of 20 ozs. per diem, or 8 lbs. 12 ozs. per week. In a population of 4,000,000 there will be 666,666 family units of six persons each, for whom the quantity to be removed will be about 91 lbs. per week, or 2 tons and 2 cwt. per annum, or for the whole metropolis 1,478,758 tons. If now the 666,666 families of six persons be divided among 40 stations, each of the latter will have the care of some 16,666 families or houses. If we again divide each station by 34 and call them "sections," each section will represent 490 houses or families. Experiment assures us that the tanks need not be emptied oftener than once a fortnight, and judging from the amount of work performed by the dustmen, there can be no doubt that forty or more houses in a day could be well and easily attended, so that in the 12 working days of the fortnight the 490 houses of the section will have been attended to, and so on by repetition throughout the year. For the work of a section two horses, a light waggon, a man and boy will make ample provision, and the expenses of the section multiplied by 34 and then by 40 will give us the total expense for the whole metropolis; thus for each section:—

	Per week. £ s.		Per annum. £ s.
2 horses, including keep, shoeing, harness, and depreciation, say	3 0	..	156 0
1 man 25s., boy 12s.	1 17	..	96 4
Waggon and stables	0 11	..	28 12
Officials and officers (quota)....	0 3	..	7 16
	£5 11		£288 12

34 sections £9,832 8s. od. per annum, constituting a station.

40 stations £392,496, which is the expense for the whole metropolis.

To balance this expenditure on the cleansing of London, we have now to consider what would be the value of the material to be carried?

At the conference of this Society before referred to, it was stated that unmixed, solid human excreta had a theoretical value of 30s. per ton; and Mr. Alfred Taylor, of Romsey, has said that the lowest value of human solid excreta was not less than 4s. per annum for each person. This would give a value of 24s. per annum for the product of each family of six persons. In order to make a computation quite within any doubt of the true value, it is here assumed to be worth 15s. per annum for each family of six persons, or 2s. 6d. each person. On this basis, therefore, we may set out for—

	Probable weight to be carried per annum.	Value per week.	Value per annum.
	tons cwts.	£ s.	£ s.
The Section of 490 houses	1,056 5	7 1	367 10
The Station of 34 sections...........	36,968 19	239 14	12,495 0
The metropolis of 40 stations	1,478,758 0	9.588 0	499,800 0
	Less working	expenses ...	392,496 0
	Profit balance	....	107,304 0

If we suppose that a capital of £250,000 would suffice to establish the plant and organisation sketched out, the payment of 5 per cent. interest on that sum amounting to £12,500 per annum, would leave over £94,000 per annum of unappropriated interest, or something over 37 per cent. This looks too good to be true, but we can only invite inquiry, confident that every pains has been taken to exclude error. One fact alone is sufficient to assure us that the estimate cannot be far wrong, that, namely, of the value of the solid excreta, which ordinarily is valued at 30s. per ton, or 4s. per head per annum. The basis of value in this calculation is 2s. 6d. per head per annum, or 15s. for the family of six persons. This fact is the central element of accuracy, because the proportion of earth employed will not affect this estimate, as we have allowed for the largest proportion ever likely to be required, and every diminution of that quantity can have the effect only of improving the balance of profit, as requiring less labour and cartage expense. If this reasoning be correct, we may nail the amount of profit herein predicted to the mast as our fighting encouragement, and say that it cannot be less. The railway authorities will carry earth at the rate of 1½d. per mile the return journey.

Enabling law to secure the regulations necessary for a successful adoption of the plan.—In view of the great importance of the subject to the health and well-being of the

community, the Legisture might well be asked to sanction such an enactment as follows:—"That every householder shall he held responsible for the management of the refuse organic matter of his house and family, and be required to consign it directly to a waterproof tank of metal supplied with dry earth sufficient for its absorption and deodorisation, into which nothing shall be put but the solid dejecta of the family. Also that he will cause all waste, bath, and culinary water, together with all urine other than that which may naturally escape with the solid dejecta, to be cast away into the existing drains and sewers. Any contravention of this enactment to be punished by a heavy fine on conviction."

To put this method on its trial it would be sufficient in the first instance to establish a section of 490 houses, which could be done at a very trifling expense, and if successful, within another year the whole of the metropolis might be transformed from a cauldron of evil more hideous and monstrous than the world has ever known before, engaged perpetually night and day in the unholy work of distilling poisonous gases for the injury and despoilment of mankind, into a true Hygeia—a city of purity and health, harmoniously maintaining unbroken the laws which sustain the chain of life, from earth to plant, from plant to animal, and back again to the earth.

I will now very briefly advert in advance to a few difficulties and objections which may be urged against the system. First, as to the apparatus, the question may be asked, "Are you sure that it will give the conveniences and the comforts of the water-closet?" In reply, we may fairly say that if—as in the Brighton experiment, where all the conditions were of the humblest and most primitive character—the two great desiderata of perfect cleanliness and absence of all odour were never for a moment absent, that such results may be insured generally; for the success there depends upon two elements which are secured by the scheme, namely, the proper kind and quantity of earth applied at the instant when most effective, which is obtained by use of the liner, and which at the same time effectually shields the apparatus from being soiled. The other element of success, namely, that the receiver shall never be made the receptacle of anything but the solid dejecta, is secured by the penalty attached to the infringement of the law, which infringement would be at once detected by the appointed official.

Another difficulty, when I first proposed a scheme of this kind in 1867, was started as to the impossibility of obtaining the earth required, and one objector suggested that it would result in unseemly hollows, gaps, and holes on the fair surface of the land, but when it is remembered, as Professor Way avers, that the scraping of the surface of one square acre to the depth of 1 in. gives 100 tons, we need have little apprehension on this score.

The agriculturists and the gardeners will send the portion of poor land they wish fertilised, and for every ton they send they will receive the same back, with the addition to it of about 18 cwts. of the most condensed and rich fertilising matter, absorbed and fixed before putrefaction, that is at the moment when its state is most perfect for the purpose; and in the form most useful and serviceable for his purpose, namely, ready for immediate use, or for storage. The probabilities are that instead of being worth the given estimate of, say, 7s. 6d. a ton, it will prove to be five or six times more valuable. If then, with the calculation made as described, a balance of profit results, of over £90,000, after paying a 5 per cent. dividend on the capital, it would seem, putting aside for a moment the more important objects of health and happiness, that even in a financial point of view, the inquiry is worthy a careful consideration.

Again, it has been objected that our streets would be blocked by the number of waggons concerned in this undertaking. There is an analogous labour always going on around us in the form of dust removal. In this neighbourhood the dustman is bound by his employers to empty the dustbins of every house once a week, and on inquiry I am informed that the men remove from each house from 3 to 6 or 7 large baskets of dust, necessitating the descent and ascent of the area steps as many times, and that they manage to empty on an average six such dustbins in the hour The removal from the earth tank once a fortnight of a much less amount, demanding only one or two ascents of the area steps, would make the earth removal a very easy affair as compared to the dust.

Again a comparison may be made with the amount of coal distributed into London houses. According to the city article in the *Times* of January 3rd, in this year, no less than 11,140,575 tons of coal were brought into London last year (1884), this being less by some 25,740 tons than the year before, and in both cases irrespective of other large

quantities imported for consignment abroad. So that the coal traffic exceeds by some eight times that estimated for the earth, and yet London streets are not blocked by the coal or dust-carts, or by both together.

In conclusion, I beg permission to repeat a statement I made in 1867, on an occasion similar to this, namely, that I have no personal interest of any kind in the great subject I have ventured to bring before you this evening, and that the motives which lead me to move for the reform I seek are entirely of a public and philanthropic nature. It is the more incumbent on me to make this declaration now, and as emphatically as I can, because the new apparatus submitted to you has been patented by me, but not in my own interest, and only for the benefit of an industrial school, to which every profit resulting from the manufacture is to be devoted. Hence the closet has been designated "The Industrial School Closet."

A beloved "master in Israel," the late Charles Kingsley, might have written the words with which I close this paper expressly for its illustration, so aptly and powerfully do they point to the evils and dangers of opposing natural law. He says:—

"I will tell you what is ten times, and ten thousand times, more terrible than war—outraged Nature. She kills, and kills, and is never tired of killing, till she has taught man the terrible lesson he is so slow to learn—that Nature is only conquered by obeying her. Man has his courtesies of war; he spares the woman and the child. But Nature is fierce when she is offended, as she is bounteous and kind when she is obeyed; she spares neither woman nor child. She has no pity; for some awful but good reason she is not allowed to have any pity. Silently she strikes the sleeping child with as little remorse as she would strike the strong man with the musket or pickaxe in his hand. Ah! would to God that some one had the pictorial eloquence to put before men and women the mass of preventible suffering, the mass of preventible agony of body and mind which exists in England year after year!"

II. — REMOVAL OF HOUSE REFUSE INDEPENDENT OF SEWAGE.

By B. W. Richardson, M.D., F.R.S.

I have only two observations to make on what I understand to be the purport of Dr. Hawksley's paper, which I regret I only know in general terms, having been engaged and unable to be present at its reading. I think I should say this much, that whatever may be the value of the earth system in London and in large towns, certainly it answers uncommonly well in the country, and under special circumstances. I had an opportunity, through the kindness of my excellent friend, Mr. Marmaduke Bell, who I think is here to-night, last summer of seeing this system well brought out in his beautiful little chateau, Fort St. George, at Rodboro', near Stroud. There the circumstances are such that water purification of sewage would be practically impossible, but in the beautiful place which Mr. Bell was kind enough to place at my disposal for three months, we had the earth system carried out within the house and outside, and we found it answer every possible purpose. We had no odour within the house at all, and there was really no trouble connected with the use of the closets. The earth was utilised afterwards on the land, and that seems to me will be the only practical difficulty—to find sufficient space in small places to remove it. Of course if we have a garden, as at Rodboro', we can have it removed directly and found useful. I am not sure how far the plan will extend to large towns, as I believe Dr. Hawksley suggests, but I am quite sure the whole subject, as he has placed it before the meeting, will deserve its best consideration. I would like to connect with that observation the reconsideration of a point which I brought forward when I read a paper here last year. That has reference to the ventilation of drains of houses. You will remember, perhaps, I specially dwelt on the absurdity of a man in London having to ventilate the main drain of his house into a space above the house—into the open air. I said it showed a fundamental error in drainage which certainly should not be permitted. If every house in London were to be ventilated in that way, in time, and under some circumstances, the air would be necessarily vitiated from that cause; and, indeed, once, when there was a great epidemic raging in London, more than a century and a-half ago, the College of Physicians petitioned that this method of ventilating house drains should not be carried out, because it was conceived, and very properly, that the air was polluted by this means. I live in a house where my dressing-room looks out on a series of houses that stand at a right angle, and, to my mind, my neighbours have properly ventilated in this way, as I have myself; but when the wind is northerly, I notice, supposing there is no smoke from the chimneys, that if I set my dressing-room

window open in the morning, the odour from the pipes comes down into the room, and I have to shut my window to keep it out of the house, but if there is smoke from the chimneys, the odour is not detectable. This leads me to say what, perhaps, many will object to very much, but I think it is quite true, that so long as this method of ventilation goes on, the idea of the purification of London from smoke will be rather a bad than a good hygienic measure, because that cloud of carbon which diffuses itself from the chimneys, although objectionable, is yet a very great purifier, acting, as carbon does generally, in destroying organic matter. I think that while London is in its present condition, as regards want of sewer purification, there is no great object to be attained, and no great virtue would be obtained, in removing the smoke, In fact, of the two evils, it is, perhaps, best to endure that which we have got, than to run the risk of having a clear atmosphere polluted by emanations from the drains, through the so-called ventilating pipes.

Removal of Refuse.

I now pass to the consideration, for a few moments, of the removal of that part of the refuse of towns which is not connected with the sewage. That is a work which has to be done independently of the removal of sewage. We have to remove the house refuse, the trade refuse, the market refuse, the street sweepings, the condemned food, the offal from the slaughter-houses, and the stable refuse. These are the different substances which have to be removed independently of the sewage, and a very large amount of refuse has to be removed in this way. My excellent friend, Colonel Haywood, the engineer to the City of London, so well known as the architect of the famous work the Holborn-viaduct, calculates that in the square mile of the City, with 50,000 residents, 350,000 day population, and 750,000 what we may call in-and-out population during the day, there are 61,230 cart-loads of this refuse to be removed per annum, in which he does not include the stable refuse, nor the offal from slaughter-houses.

We have to consider, as sanitarians, what mischief this refuse does, as apart from the sewer refuse. On this matter there have been many opinions, at various times. I suppose there is no subject in sanitation that has such an ancient history as this question of removal of refuse. After the second great plague of London, which occurred in the reign of Edward III., the King in Parliament issued a proclamation on this subject of refuse, with special reference to the refuse of slaughter-houses. The refuse, Parliament thought at the time, was conducive to the plague, and an Act was passed insisting that the killing of all animals should take place at Stratford and at Knightsbridge. The same subject came up again in the year 1636, in the reign of Charles I. That was at the instance of the Royal College of Physicians. Slaughter-houses had again been brought into London, and at the instigation of the Royal College of Physicians they were again expelled. In 1665, the same thing occurred once more. And, again as late as 1854, the Board of Health at that time, when cholera was prevalent, through Dr. Sutherland, reported almost in the same terms. The refuse of the slaughter-houses seemed to be that which was most dreaded. It must, however, be confessed that the great evil, in the times of the plague, arose from sewage, because we know that in the great plagues the Fleet ditch was the point nearest which the highest mortality took place, and that it was a ditch which received sewage as well as offal from slaughter-houses and all other refuse.

Evils from Extra Refuse.

Later observers have varied in their opinion as to the amount of evil done by the extra refuse. Some have thought that very little mischief comes from it at all, and that is the opinion which is practically taken by Colonel Haywood. Colonel Haywood argues that there is very little mischief because there are so few people connected with the mischief who are affected by the exhalations which come from this refuse. He says:—"The men and women employed in raking and sorting the dust work in the open air on the banks of the Thames, and appear to the ordinary observer (and most people can judge fairly well of what is unhealthy in the appearance of our race) to have good health. Your superintendent informs me that this has been a point of constant observation with him since he has been in your service (a period of thirteen years), and that he is certain they enjoy excellent health. Whether they are subject to zymotic diseases more than other people in their class in life, who work in so-called unhealthy occupations, it is not for me to say (and reliable statistics on this point may be almost impossible to obtain), but I may remark

that the effect of this and similar classes of employment upon the health of the work people has been the subject of much investigation from the time of Parent du Chatelet, who wrote largely upon it up to 1832, and others who have investigated and written since, without, apparently, having established clearly that such occupations are seriously harmful. It will be in the recollection of the Commission, if not upon its records, that the allegations of the unhealthiness of those employed in gasworks or living in their vicinity, broke down utterly in the Parliamentary inquiry made in the year 1859; it is probable that allegations about the injurious effect of dust-yards and wharves might be similarly controverted if the same energy be employed in the investigation that was shown by the gas companies at the time named."

I have myself tried to ascertain whether there is any specific case to be brought against the effects of this refuse as producing particular diseases. I made a special inquiry, in 1861, in regard to scarlet fever and its relation to dustbins, and to sources of offensive smell from these external causes. I am bound in all honesty to say that I never could detect any direct connection between the existence of scarlet fever and these decomposing materials, and the same with other diseases. There is no apparent direct connection, but then that same objection which Colonel Haywood has raised with regard to this refuse might refer also to sewers, for, from an inquiry I made as to the health of sewer men at that time (1861), I got the same results. I did not find sewer men more than the rest of the community were affected with zymotic disease. I extended the inquiry to undertakers. Twenty years ago, I made inquiries into the matter as to the undertakers of London, so far as I could arrive at the facts, and I could not find that their occupation exposed them more than any other occupation to zymotic or contagious diseases. They were, in fact, freer than the doctors, which led me to infer that after persons died of fever and infectious diseases, the emanations causing fever did not spread as they do in life. We must not, however, I think, arrive at the conclusion that this refuse matter does not give out gases which are injurious to life. Probably the difficulty lies in this, that the gases are not direct factors, but are indirect factors; and I think we shall be obliged in the future, in studying the origin of diseases—not only from the exhalations from this refuse, but also from the sewers—to consider that there are two factors, one, the peculiar condition of the atmosphere itself, which is not yet understood, but to which the great Sydenham gave the name of the epidemic condition of the atmosphere, and the other an influence supported by the presence of noxious vapours arising from the decomposition of these organic materials. If that be true, we need not suppose that these agents of themselves produce particular diseases, but when they are assisted by some as yet undiscovered quality of atmosphere which tends to the production of cholera, typhus fever, diphtheria, scarlet fever, and which tends to the favouring of direct communication of these diseases from individual to individual, then the evils arising from these agents come into play. They, therefore, although the direct evidence against them may be weak, should be removed, and the more rapidly they are removed the better for the health of the community. It seems again to be the fact that in the towns where there is quick removal, and where there is freedom from all odour arising from decompositions, there is less disease, which shows that these agents certainly have an indirect effect at all events.

Removal of Extra Refuse.

I pass now to the study of removal. Everything about the removal, except perhaps in the City, is at present bad in parts of London, and in many large towns, and this I think should not be the case, because we find, on the very best authority, that there is a profit arising from the removal. Colonel Haywood shows that, in the square mile forming the City of London, there is a gain to the City from the sale of this lost material, as it may be called, amounting to a little over £2,000 a year. The quantity that is removed I have told you, and the gain is certainly very considerable. £2,000 a-year, he says, may be cleared by what is sold, and he tells us what this refuse is that is sold. It consists of the house refuse, viz., ashes, cinders, paper, rags, broken crockery, bones and vegetable matter. The trade refuse, consists of paper, string, straw, wood, shavings, and so forth. The market refuse is mainly vegetable matter. The street sweepings are chiefly the dung which is collected from the streets. The other substances which the Colonel has not referred to, is the refuse from the stables, and the other

item of offal from the slaughter-houses. Taking these two away, the refuse from the stables and slaughter-houses, there was still a gain on the remainder of £2,190 for the sale of this refuse, after that which was useless had been burnt, the sale consisting chiefly of what was picked out in the way of pots, bottles, and things of that kind, and the value of the refuse which was taken off from the streets. The amount obtained in the City might be gained in the metropolis at large.

In many large towns the extra refuse is collected in one great ash-pit, and there the sorting takes place. There are several large towns in the country where we find this large ash-pit. There they select all the things which are saleable, and then, sometimes for weeks together, in some of these towns, the decomposing matter lies for several days or even weeks before it is taken away. In the City, they have a very definite way of removal. In the City all that is destructible and useless they burn. The refuse goes down to Lett's wharf. "The house and some of the trade refuse is forked over and sorted; leather, iron, glass, crockery, and certain other materials are separated from the ashes and sold to various dealers; the ashes and breeze are sifted and sold to brickmakers. All these materials are, with the exception of a trifling quantity of vegetable refuse, generally dry, and the smell from them is but slightly offensive. Their removal from the wharf is made daily. The street sweepings and animal and vegetable refuse, removed from the markets, and from the premises of large traders, are got rid of together; the market refuse is at once mixed with the sweepings when they are dry, or nearly so, and shot from the carts into barges, which are always lying at the wharf ready to receive them. Barges leave with this material daily; it is but rarely, in fact, that any offensive matter remains at the wharf twenty-four hours after it arrives there. The street sweepings, when in large quantities, and in a state of slop, are not at all times shot into the barges, but are thrown down on to the wharf, and mixed with straw and dry material; the water rapidly drains away from them, and the residue is then mixed with street sweepings, stable manure, or other drier matters having manurial value, is cast into the barges, and taken away by agriculturists who purchase it." That is the way in which this disposal takes place in the City. "No materials liable to decompose or be offensive are ever removed from the wharf through the public streets; old iron, tin, lead, glass, leather, paper, and a few other hard materials alone are carted away, and of these it is probable that not more than a load or two leave the wharf daily."

What is possible to burn is burnt. I do not know that there are many towns in the kingdom where so good a provision is made for the removal of the refuse as here, and I think we might take the City method of removal as a good one for a copy in other towns in England. At seaside towns it would be probably more effective to have one of the same kind of floating barges as those you see on the Tyne, which open at the bottom, and let that which is to be destroyed be taken out to sea and destroyed there. I suggested to the Town Council of Brighton that this should be the method adopted there, that a barge should be towed out at certain times two or three times a week, and the refuse let down into the sea, but it was not adopted. Where this cannot be done, all that can be destroyed by fire should be so destroyed. Condemned meat should be destroyed at once, either by being buried or, in some cases, destroyed by fire.

We have next to consider the removal of the offal from slaughter-houses and stables. In both cases I think the refuse should be removed as quickly as possible. Slaughter-house refuse very rapidly decomposes, and when the drainage is not good, the slaughter-house is a source of considerable annoyance. I believe the refuse is so valuable, that when it is well cleansed it is utilised and sold for a considerable sum, and only requires to be carried away in closed trucks.

As regards stable refuse, that should be removed daily. It is an absolute shame—and I think I shall show this better further on—that we cannot pass by any large street or square but that we see in the mews many heaps of stable refuse—in the summer-time drying, and in the winter-time wet and decomposing. It sometimes has happened that I have been obliged to pay for the removal of the refuse from my stable, and I think that, considering the value of this article for certain manurial purposes, it is a shame that any delay in removal should be allowed to occur.

In the London parishes, and in many other parishes, the irregularity in respect to the removal of extra refuse lies in bad management, and particularly in the system of con-

tracts. The system of contracts seems to be a bad one altogether. I think every parish ought to undertake the removal directly by its own servants. When they let out to contractors a certain sum is paid, and the contractors have the advantage of the use of the material; but yet there is the greatest possible difficulty in getting the refuse removed from the houses. I do not know if other gentlemen find it so, but I find that even by feeing the men who remove the dust, there is the greatest difficulty in getting the dust removed once in a week or ten days; and a little time ago, notwithstanding protest, it was three weeks before I could get dust removed.

Until better regulations can be made by the different parishes, there should be means taken in every household for meeting the difficulty. The dustbin should in no case be a square brick box. Some years ago I invented a small bin in metal, which was made by Ewart, of Euston-road, and very well it answered. I had four bins in my house, and the men could put them on their shoulders and carry them to the carts, instead of having to use baskets. These bins require to be round and small, because if they are square, the men say it causes them pain to carry them. By having them closed at the top, and closing one when it is quite full with a screw top, and taking to another, you keep your house and area moderately sweet. In like manner, in the house, attention should be paid especially to the collection of bones. Bones are most offensive things in the house. When I go, as a physician, into a house, upon going upstairs I often detect the smell of decomposing bones proceeding from the basement. The best way to meet that difficulty is by having a small round iron box with a screw top, into which the bones should be placed until they are removed.

There will always be, I think, a considerable amount of street refuse, until the streets are paved all in the same manner. It does not seem that the paving-stone method is a good one, as the manure gets trodden in, and the worst of all for the retention of poison is the macadamised road. The best surface is asphalte, and, after that, wood pavement.

I think that we ought, as a Society, in considering this question, to do the best we can, and have a daily removal of everything that pertains to extra refuse in all parts of this metropolis. I cannot believe that that would be an expensive business. Mr. Chadwick tells me that, during the time of the cholera epidemic in 1854, the Board of Health, as far as it could, did insist on daily removal, and that in some parts of London they succeeded in getting complete removal every day. This work was placed under the control of Mr. Philip Holland, who reported that, inasmuch as the same quantities had to be removed, whether removed daily or weekly, there was no greater expense in removing the smaller quantity than in letting it accumulate and then removing it.

I now come to the question of stable refuse, which is important in two ways, first, because the stable refuse is most objectionable, and next, because it is most valuable; and what I should like the Society to consider is, whether it could not be possible to induce some people to undertake the removal of this manure for the purpose of bringing one good article of food into cheap use, and that is the mushroom. There has been an attempt made by one gentleman, Mr. Barter, to do this on a small scale. Mr. Barter is a gentleman whose labours are well referred to in a little book, which has been published by Mr. John Wright, entitled, "Mushrooms for the Million." Mr. Barter has a small farm for mushrooms, but what he has he works exceedingly well. He farms one acre, for which he pays £12 a year, by the collection of manure from the mews in London, and the value of his returns is very great indeed. He considers that there is nothing at all in the way of farm produce which answers so well and pays so well as this. He says:—"After the beds are exhausted, the decayed manure," which was bought originally for 3s. 6d. per load, "usually sells readily at 1s. 3d. per yard of bed, or 2s. 6d. per load. Those having experience of manure say that no kind is better suited than this for enriching the soil in the London parks, squares, and gardens generally; it is also, as most gardeners know, excellent for mixing with soil for potting purposes. I have a little more than an acre of land, but hitherto only about half of it has been covered with mushroom beds, a portion of the rest being used for spawn-making. The beds, however, increase in number every year, and before the present season expires I shall gather at the least five tons of mushrooms, against a little over two tons last year. I send them all to Covent-garden market, where they are disposed of in the usual manner by a salesman. They are sorted into three different sizes, and are all packed in chip punnets, each containing a pound. They have

this autumn fetched higher prices than I ever knew at the same season of the year. The small buttons have been making 2s. per lb., and the larger mushrooms 1s. 6d. per lb., and the season promises to be one of the best in my experience. I should like for farmers, and, indeed, all who keep horses, also gardeners, and even cottagers, to be made acquainted with this system of mushroom culture, as they might benefit themselves considerably. At present there is, practically, no supply around large provincial cities and towns in which the prices for mushrooms usually rule about 6d. per lb. higher than in London, from whence they have to be obtained. I am not a gardener, but a carpenter by trade." Then he goes on to explain the profit that can be obtained. He says:—"Here is an instance, with manure costly, rent high, labour expensive—£4 being paid to three men weekly—of four families being supported off less than an acre of ground at the rent above named. Could similar results be achieved by the culture of any other outdoor crops of fruit or vegetables?"

If we could by any possibility turn the railway arches into places where mushrooms could be grown, and have the whole of the stable refuse of London applied to the growing of mushrooms, we should supply the community with one of the very best articles of food, and at the same time purify the air by removing one of the most objectionable odours.

CONCLUSIONS.

The following are the conclusions of my short paper:—

I.—That the extra refuse of towns and cities apart from sewage consists of—1. House refuse; 2. Market refuse; 3. Trade refuse; 4. Condemned food; 6. Offal of the slaughter-house; 7. Stable refuse.

II.—That the proportion of refuse to each person is, perhaps, from four to five cart-loads per annum.

III.—That of the refuse named, the offal of the slaughter-house has been, commonly, thought to be most detrimental to health.

IV.—That the evidence of *direct* communication of disease from the extra refuse named is not proved.

V.—That evidence seems to point to the fact, not that these refuse substances are absolutely innocuous, but that some other factor is required to render them injurious.

VI.—That a large portion of the refuse except the smallest of all—condemned food—is of monetary value, and pays for the expenses of removal.

VII.—That as the expense of removal is but little, if at all, increased by regular and complete removal from day to day, daily removal ought to be generally enforced.

VIII.—That every householder ought to assist the authorities in removal of refuse (*a*) by keeping the dust in small moveable bins, (*b*) by keeping bones in a closed iron barrel, and (*c*) by destroying all vegetable refuse on the kitchen fire.

IX.—That the only slaughter-houses that should be permitted in large communities are such as shall provide for the instant removal of all offal and other decomposing material.

X.—That all stable refuse ought to be systematically removed from day to day for the growth of one of the most nutritious foods that could be supplied to the people.

DISCUSSION.

Mr. EDWIN CHADWICK, C.B., writes:—

"Park-cottage, East Sheen,
"Mortlake, Surrey, April 15, 1885.

"There is one point which may be worth mentioning. In the examination of the private slaughter-houses we found that there were various articles—such as bladders, horns, hoofs, &c.—which, separately, were not worth collection, but which, when brought together, in the larger establishments—such as those of Paris—were made the subject of valuable manufactures. Under unity, the like must take place, and great waste would be prevented that now occurs under disunity."

The CHAIRMAN said he did not feel at liberty, in his position, to take part in the discussion, but it must not be supposed that he agreed with all that had been advanced; on the contrary, he was not altogether in accord with either Dr. Hawksley or Dr. Richardson. Dr. Richardson had very properly advocated the removal of refuse at very short intervals, and had described what was done in London; but he could assure him that this question had recently been taken up, and frequent removal was now being carried out in most of the large towns throughout the kingdom. Reference had been made to the £2,000 per annum made by the sale of the London refuse, and he often heard plans recommended on

account of the profit to be derived; but in his opinion that was not a sound argument. The duty of those who had to undertake the task of scavenging was to produce the greatest amount of cleanliness, and leave the profit to take care of itself.

Dr. ALFRED CARPENTER said he had the privilege, twenty years ago, of hearing Dr. Hawksley's views on this question at Leamington, and he felt it his duty then to aid the opposition to the scheme brought forward for dealing with sewage by the earth system, the result being that the Congress agreed with the views he advocated, and not with those of Dr. Hawksley. He would not say that earth closets were not advantageous in some places; if he had a house in the country, standing in its own grounds, with plenty of space for dealing with the refuse, and could depend on having the earth-closet properly managed by his servants, it would be preferable to any other system; but in large towns like London it was totally different. Even if the earth closets were adopted, the sewers would still remain, and would be in nearly as foul a condition as at present. This was found to be so in towns where the excreta were kept out of the sewers, and nothing went in except the ordinary washings and refuse water from the houses. Dr. Hawksley argued in favour of keeping in the house for a fortnight the very matter which was of all things most dangerous. The first point in dealing with excreta was to get rid of it entirely before it became dangerous; and it was pretty well established that danger arose, even in the case of infectious diseases, when fermentation or some process of decomposition set in. Dr. Richardson advocated—and there he agreed with him—the immediate daily removal of materials which were not one-thousandth part so dangerous as the excreta from diseased patients, especially in certain cases. It was suggested that men were to be employed so many hours a day in the removal of excreta, but was it likely that the inhabitants of Regent-street, for instance, would allow these tubs or tanks to be brought out and put into carts in the afternoon, when their shops were full of customers. There would be a smell occasionally, even with the best system of this kind, as the closets would not be managed by a class of persons who were particularly careful. Dr. Richardson had referred to the difficulty he found in getting stable refuse removed, having to pay men to do it; and this would apply more forcibly still to the earth-closet collection. He (Dr. Carpenter) had been instrumental in obtaining the introduction of earth-closets into one district, and he found the difficulties in getting them kept in order by the poor, and especially in getting the refuse removed, were very great. He was quite sure the sums mentioned would not be one-tenth of what the actual cost in London would be. With regard to Dr. Richardson's objections to sewer ventilators, it was quite possible that annoyance might sometimes be occasioned by them, owing to the defects in the London sewers, many of them being sewers of deposit, which they ought not to be; but the engineers ought to remedy that by so constructing the sewers that everything should be carried off in six or eight hours, and then there would be no sewer gas formed. If the soil-pipe of every house were made to act as a ventilator, the condition of things would be such that it would be impossible for any large amount of foul air to be discharged under any circumstances to the injury of individuals. Dr. Richardson did not seem to be at all aware of the great improvements which had been made in dealing with the refuse of a district, but if he would go to Manchester he would see a system far superior to that adopted in London; and the same in Glasgow, where the first idea was the cleansing of the town, not the profit to be made from the material. In Manchester, a certain sum was made by the disposal of the material, but still, on the whole, the process was expensive. Dr. Richardson spoke of a profit of £2,000 being made from the refuse of London. He knew with regard to his own district, which embraced 10,000 acres, and had a population of 90,000, the loss on the collection and disposal of the refuse was several thousands a year. He objected to the use of breeze in the manufacture of bricks. The ratepayers must pay for the scavenging, and the larger the area, and the greater the distance the material had to be carried, the more expensive it would be. Some two years ago, the Medical Officers of Health appointed a committee to inquire into this matter; several meetings were held, and an endeavour was made to see if the railway companies could be induced to carry away this refuse on such terms as would make it easier to deal with; but they would not have anything to do with it, except on ordinary commercial principles. The result was that, in some districts at least, even stable manure was not worth the expense of the carriage. He quite agreed that these matters should be in the hands of the local authorities, who must bear the expense of keeping the place clean without regard to profit. With reference to the utilisation of water-carriage to get rid of refuse, he held that so long as we had sewers—and sewers we must have with a water supply of 25 to 30 gallons per head per day, and there was a silent highway to help carry the refuse to its proper destination, the land—these means should be made use of. He did not say there was a profit to be made by applying it to the land, such as Dr. Hawksley said would accrue from the dry earth system, but it was a duty the country owed the land to return to it that which had been taken from it; and if the sewage of London were distributed on the area round it which was now unproductive, hundreds and thousands of acres which were now not worth 5s. an acre, might be made very valuable The City of London would not get the profit, but the agriculturist. The town must pay for the cost of removal, and for the difference between the value of the land as agricultural land and the price put upon it when required for a sewage farm. The agriculturist who used the sewage was

entitled to more than the ordinary profit, because he had more than ordinary difficulties and risks to encounter. The risk, however, was not that of any danger to the public health. In his own district, a farm of 600 acres had been worked for twenty years with the sewage from a very large district. He did not say it had always been well managed, for it had not, but it had not injured public health in any shape or way; and he could say, from his own experience, that those who used the material, and those who consumed the produce, had not suffered at all, and the general health had rivalled that of any district round London.

Mr. H. H. COLLINS said he had had considerable experience of earth-closets at Woking, where they were largely employed; at Derby, in Messrs. Strutt's mills; and at Ashford, but Dr. Hawksley seemed to have forgotten the defects which attended their use, and which were by no means confined to their use by the poor. He had been in the basements in many of the houses in Regent-street, the sanitary condition of which was anything but satisfactory, and with the large crowd of persons employed in some of these establishments the difficulties would be very great. Not only was a large quantity of earth required, but it must be suitably prepared; and remembering that all the dejections were not solid, the result would simply be a pool of noxious mud. In some of those establishments there were as many as 300 persons, and the accommodation was of a very limited description. What was to be done with the present arrangements? There had been a great demand of late for a constant water supply, and the great obstacle which prevented the carrying out of this much-needed improvement was the difficulty of getting rid of the existing fittings. It would be much more difficult to re-arrange the whole of the drainage. Even if the system had all the advantages which Dr. Hawksley claimed for it, it had this great fault, that it proposed to make a profit out of the business, and all experience showed that this was quite impossible. Under any circumstances it was difficult to get domestics to properly attend to the closets; and if generally introduced, he was sure they would soon become a nuisance. Dr. Richardson commenced his paper by animadverting on the numerous ventilating pipes which disfigured his neighbourhood, and the annoyance they sometimes occasioned him; and he (Mr. Collins) was rather pleased to hear it, for it showed that these ventilators were doing their duty, which was sometimes doubted. But Dr. Richardson did not say whether he had ascertained if these pipes ventilated the sewers or only the house drains, as they ought to. Many sewers were simply sewers of deposit, and with old sewers this could not be avoided; but all new sewers were laid where the gradients admitted of it, so as to be self-cleansing. And if there were a proper interception between the sewer and the house drainage, the small amount of foul air which would pass up the pipes would not affect even the olfactory nerves of Dr. Richardson. With regard to the removal of refuse, he should say the City of London was quite a baby in the matter. It had only just taken it up; but in Manchester, Nottingham, Leicester, and other large towns, the system was in full operation. In Manchester they did not hope to make any profit; they were satisfied if they did not make any loss. A model of the apparatus was shown in the Health Exhibition, and when he visited the works, they were endeavouring to distil some beautiful scent from some of this unpromising material. Recent legislation had disposed of the question of slaughter-houses, and in the city of London none were licensed unless certain precautions were taken. With regard to dust, again, Dr. Richardson must have seen in the Health Exhibition hundreds of iron or zinc dustbins, and no sanitarian would think of building a house in which the old-fashioned receptacle was not replaced by some one of these modern appliances, which could be easily removed and emptied. He found no difficulty in Paddington in getting the dust removed.

Mr. WALLER agreed with Dr. Carpenter that if every house which was connected with a sewer were compelled to assist in the ventilation of it, there would be no stagnant air to cause a nuisance, but a constant current, and this ought to be provided for by architects. The £2,000 which had been spoken of was the amount derived by the Commissioners of Sewers from the sale of the refuse material; it was not a profit in any sense of the word. They had recently erected a destructor, like that at Manchester, at a cost of £10,000, and that would only destroy about a third of the refuse collected in the City. Of course, there was a great loss on the whole; nearly $4\frac{1}{2}$ million gallons of water were used for cleansing the sewers, at a cost of £18,000 annually. The object was not to make a profit, but to keep the City clean, and seeing that the streets were swept or washed every ten hours, he did not think a more healthy town could be found. They often had complaints about the gratings in the streets, and in such cases they allowed them to be closed, if the party complaining would himself fix a 6-inch pipe from the sewer to the highest point of the adjoining building.

Mr. LIGGINS said he had been for some years on the committee of the Vestry of Kensington which had the cleansing of the parish under its charge. He believed there was an enormous deal of exaggeration as to the evils of the sewerage system. He had no particular sanitary arrangements in the house in which he had lived for 27 years, but during all the time he had never had a doctor in the house on account of any of the diseases which were usually attributed to sewer gas. He was astonished at any gentleman recommending the retention of this offensive matter boxed up in the back yard for a week or a fortnight,

and the drawing produced to show how the system could be introduced into a house of many floors, was quite impracticable. Again, where could you get sufficient earth for the requirements of four millions of people; and where was the land on which manure was to be placed afterwards? The greatest difficulty they had in Kensington was to find a piece of ground the size of that room on which to place their refuse. The City of London consisted of one square mile, and possessed an advantage which no other parish had, of a great river running through it. There was not a mile of cartage to be done; Kensington extended from Sloane-street to Kensal-green cemetery. They had tried in vain to get land for a wharf on the Paddington canal; they had one at Cremorne, which served one portion of the parish, from whence the refuse was taken in barges to Kent, some to be used as manure, and some to be burned into bricks. The rest had to be carted to Acton, and they had great difficulty in getting rid of it. They did the work themselves, and had a large staff of men and 115 horses, but they could only remove the refuse once a week. The manure from all these horses was valuable, but they had a difficulty in getting rid of it, for the price of vegetables was so low, that market gardeners could not afford to buy it, and they had to pay £5 a barge-load to have it taken away. If it were all used to grow mushrooms there would be such a glut that they would be worth nothing; as it was, he knew a mushroom-grower who found it difficult to dispose of his produce.

Mr. J. Shaw (Medical Officer of Health for Rotherhithe) said his district was very poor and very populous, and if earth-closets were to be introduced there, in the first place it would involve a great expense on the proprietors of houses, and in the next the people would not keep them clean. There was the greatest difficulty in making them keep even the houses clean, and the closets were always out of order from all sorts of things being thrown down them. If the railway arches from London-bridge down to Bermondsey and Greenwich, which were close to houses, were filled with manure for the purpose of growing mushrooms, the stench in the summer time would be insupportable.

The Chairman said he agreed with Mr. Collins as to the condition of the sewers; but one great remedy for deposit in them was systematic automatic flushing. Every sewer ought to have a sufficient volume of water passed into it to carry away any matter which might be deposited there. He had recently established a flushing tank in his own house which received all the waste water from the housemaid's sink and bath, and also a portion of the roof water; so on a wet day it would probably flush every quarter of an hour. His experience as to complaints of sewers was very wide. He had constant complaints of street ventilators, but in all these cases the sewers were comparatively dry; the water which went in percolated away into the subsoil, and then the refuse remained, became putrid, and gave off offensive smells. Where the remedial measure of establishing flushing tanks had been carried out, the evil had disappeared. With regard to general refuse, destructors were being put up in most of the great towns, for consuming by fire the refuse of the dustbins; in seaport towns it was found more economical to use hopper-barges and take it out to sea. There were two modes of dealing with excreta in this country—the wet system, and the pail system; in a few cases also the earth-closet. The pail system, he was sorry to say, was adopted in a number of large towns; but although the value of the manure was supposed to be from 4s. to 6s. per head per annum, where it was dealt with in the most liberal manner, as at Rochdale, and was supposed to produce manure worth £5 per ton, the system was worked at an annual cost of £10,000 or £12,000. He knew of no instance where it was not a horrible nuisance, and very costly. If Kensington did its own scavenging, he congratulated the parish. This ought never to be the subject of contract, for the contractor in fine weather made a large profit, and in a bad season the streets and people suffered. The removal of the excreta, whatever value it might have, must be paid for. There had been something like 350 patents during the last twenty years for dealing with excreta for manure, but he did not know of one which paid. Irrigation was the most likely to show a profit, but he did not know of any sewage farm, even the best managed, that had succeeded in paying a rent and making a profit. Where well managed, it was less costly to the community than precipitation and chemical processes, which cost about £1,000 per annum for every million gallons of sewage. For ten or twelve years, Coventry subsidised a company with £2,200 a year for dealing with 2,500,000 gallons of sewage per day, but the company became bankrupt, and the town had to undertake the work itself. Speculators in this matter generally neglected the important element of seasons. A wet season prevented any possibility of making a profit from a sewage farm; and in a favourable season, all the surrounding farmers had good crops, and could supply customers equally well; and the sewage-grown produce accumulated to such an extent, that it could not be disposed of at anything like the fancy prices it fetched on other occasions.

Dr. Hawksley regretted that he had so little time before him to reply, as he felt that it was impossible to do justice to his argument so hurriedly. He thought that much of the adverse criticism would have been spared had the speakers realised the facts stated in his paper, where objections made had really been foreseen and answered. For example, it was remarked by Dr. Carpenter and others that, while every one saw the necessity of removing refuse matter

at very short intervals, he proposed to keep it in the tanks fourteen days; overlooking the fact stated in the paper that, in consequence of the immediate chemical changes which ensued when dry earth was placed in contact with organic matter, no subsequent putrefaction occurred; that the ammonia and other elements were at once locked up, and could never again be injurious. It was also said that under the proposed system the sewers would be as foul as ever, in this ignoring the provision made that, were the system established, every inlet to the sewers would be guarded by a grating sufficient to prevent any solid matter entering them. Also that the apparatus would not be kept in order by the servants, ignoring again the provision that its success did not depend upon such attention, which would be confided to the officials made responsible for that service. Mr. Liggins stated that the evils of the sewage system had been exaggerated, forgetting that the description in the paper was taken from the personal experience of the members of the Royal Commission. Mr. Shaw objected to the expense and difficulty of replacing water-closets by earth-closets, the answer to which objection is that it is in fact both easy and inexpensive. Without some expenditure no public improvements can be effected, and the proposed one is of vital importance to the community. As to the curious fact that persons employed in unwholesome occupations, and exposed, for example, to sewer gases, in many cases appeared to feel no evil effects, this was probably to be accounted for on the principle of tolerance, or habit, which enables the human constitution to accommodate itself to adverse influences. He felt confident that the day must come when such a system as he advocated would be adopted, and the erroneous and most evil one of water-carriage be abolished.

The CHAIRMAN then proposed a vote of thanks to Dr. Hawksley and Dr. Richardson, which was carried unanimously.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The Prince of Wales has signified his intention of making a tour of inspection through the principal galleries on the occasion of the opening of the Exhibition by His Royal Highness on Monday, May 4.

COLONIAL AND INDIAN EXHIBITION.

The first meeting of the Royal Commission appointed by the Queen for the purpose of organising a Colonial and Indian Exhibition in 1886, was held on the 30th March, under the presidency of H.R.H. the Prince of Wales.

His ROYAL HIGHNESS, in opening the proceedings, said:—

MY LORDS AND GENTLEMEN,—In addressing you for the first time, I would remind you that the objects for which her Majesty has been pleased to appoint this Commission are, briefly, to organise and carry out an Exhibition by which the reproductive resources of our Colonies and of the Indian Empire may be brought before the people of Great Britain, and by which also the distant portions of her Majesty's dominions may be enabled to compare the advance made by each other in trade, manufactures, and general material progress. This project, to the realisation of which I have looked forward for some years, is essentially one of a national and imperial character, diffeiing in this respect from former Exhibitions, in which the elements of trade rivalry and profit largely predominated. No such opportunity of becoming practically acquainted with the economic condition of our Colonies and the Indian Empire has ever been afforded in this country. The attractive display in the Indian and Colonial Courts at the Paris Exhibition of 1878 could only be witnessed by a comparatively small number of the population of these islands, millions of whom may be expected to view and profit by the evidence which the Exhibition of 1886 will afford of the marvellous progress made by their fellow-countrymen beyond the seas. I also trust that this gathering may serve even a higher purpose, and be the means not only of giving a stimulus to commercial interests and intercourse, but of strengthening that bond of union between her Majesty's subjects in all parts of the Empire, the growth and manifestation of which are most sincerely appreciated by us all. I have to announce that arrangements have been made by which the buildings and grounds at South Kensington, where the Fisheries and Health Exhibitions were recently held, have been placed at the disposal of this Commission, on fair terms, and the buildings can be made available for our purposes at a moderate outlay. I therefore caused plans of these grounds and buildings to be prepared, showing the space which the Commission could assign to India and to the various Colonies, and the arrangements which were deemed most convenient. These were communicated to the Government of India, to the High Commissioner for the Dominion of Canada, to the various Agents-General of the Colonies, and, through the Colonial-office, to the Crown and other Colonies, and have met with their approval. Similar communications have been made through the Secretary of State for the Colonies direct to the various Governments, and to the Secretary of State for India with like results. In the despatch which contained this information, I also stated it was considered advisable that, in place of any awards being granted by juries, as has been the case in previous Exhibitions, commemorative medals only should be

given to each exhibitor. The object in suggesting this change was, that as some Colonies, from their age and circumstances, were more advanced than others, those in their infancy should not be placed at an undue disadvantage in an Exhibition from which all thoughts of trade rivalry should be excluded. I am pleased to say that answers have been received which show that the suggestions made on this and other matters have been favourably accepted; and to inform you that the project of holding the Exhibition has been everywhere received with the utmost cordiality.

Sir PHILIP CUNLIFFE OWEN read the correspondence relating to the appointment of the Commission, and the participation of the various Colonies, all of which were most willing to take advantage of this opportunity of displaying their resources and progress, and gaining a larger knowledge respecting their sister Colonies.

The Earl of DERBY proposed, and the Earl of KIMBERLEY seconded, a resolution to the effect that the Commission entirely approved of the arrangements made by H.R.H. the Prince of Wales, the Executive President.

The total amount of the guarantee fund up to the 30th of March, was £147,950.

BOXWOOD AND ITS SUBSTITUTES.

By JOHN R. JACKSON, A.L.S.,
Curator of the Museums, Royal Gardens, Kew.

(*Continued from p.* 569.)

Natural Order Sapindaceæ.

8. *Acer saccharinum*, L. (Sugar, or Bird's-eye Maple).—A North American tree, forming extensive forests in Canada, New Brunswick, and Nova Scotia. The wood is well known as a cabinet or furniture wood. It has been tried for engraving, but it does not seem to have attracted much notice. Mr. Scott says it is sufficiently good, so far as the grain is concerned. From this it would seem not to promise favourably.

Natural Order Leguminoseæ.
Sub-order Papilionaceæ.

9. *Brya Ebenus*, A. DC. — A small tree of Jamaica, where the wood is known as green ebony, and is used for making various small articles. It is imported into this country under the name of cocus wood, and is used with us for making flutes and other wind instruments. Mr. Worthington Smith considers that the wood equals bad box for engraving purposes.

Natural Order Rosaceæ.

10. *Pyrus communis*, L. (Common Pear).—A tree, averaging from 20 to 40 feet high. Found in a wild state, and very extensively cultivated as a fruit tree. The wood is of a light brown colour, and somewhat resembles limewood in grain. It is, however, harder and tougher. It is considered a good wood for carving, because it can be cut with or across the grain with equal facility. It stands well when well seasoned, and is used for engraved blocks for calico printers, paper stainers, and for various other purposes. Pear-wood has been tried for engraving purposes, but with no great success. Mr. Scott's opinion of its relative value is referred to under pai'cha wood (*Euonymus Sieboldianus*).

11. *Amelanchier canadensis*, L. (Shade Tree or Service Tree of America).—A shrub or small tree found throughout Canada, Newfoundland, and Virginia. Of this wood, Porcher says, in his "Resources of the Southern Fields and Forests, "upon examining with a sharp instrument the specimens of various southern woods deposited in the museum of the Elliott Society. . . I was struck with the singular weight, density, and fineness of this wood. I think I can confidently recommend it as one of the best to be experimented upon by the wood engraver."

12. *Cratægus Oxyacantha*, L. (Hawthorn).—A well-known shrub or small tree in forests and hedges in this country. The wood is very dense and close grained. Of this wood, Mr. Scott reports that it is by far the best wood after box that he has had the opportunity of testing.

Natural Order Myrtaceæ.

13. *Eugenia procera*, Poir.—A tree 20 to 30 feet high, native of Jamaica, Antigua, Martinique, and Santa Cruz. A badly seasoned sample of this wood was submitted to Mr. R. H. Keene, who reported that "it is suited for bold solid newspaper work."

Natural Order Cornaceæ.

14. *Cornus florida*, L. (North American Dogwood). — A deciduous tree, about 30 feet high, common in the woods in various parts of North America. The wood is hard, heavy, and very fine grained. It is used in America for making the handles of light tools, as mallets, plane stocks, harrow teeth, cogwheels, &c. It has also been used in America for engraving.

In a letter from Professor Sargent, Director of the Arnold Arboretum, Brookline, Massachusetts, quoted in the Kew report for 1882, p. 35, he says:—"I have been now, for a long time, examining our native woods in the hope of finding something to take the place of boxwood for engraving, but so far I am sorry to say with no very brilliant success. The best work here is entirely done from boxwood, and some *Cornus florida* is used for less expensive engraving. This wood answers fairly well for coarse work, but it is a difficult wood to manage, splitting, or rather 'checking,' very badly in drying." This, however, he states in a later letter, "can be overcome by sawing the logs through the centre as soon as cut. It can be obtained in large quantities." Mr. R. H. Keene, the engraver before referred to, reports that the wood is very rough, and suitable for bold work.

Natural Order Ericaceæ.

15. *Rhododendron maximum*, L. (Mountain Laurel of North America).—Of this wood it is stated in Porcher's "Resources of the Southern Fields and Forests," p. 419. that upon the authority of a well-known engraver at Nashville, Tennessee, the wood is equalled only by the best boxwood. This species of *Rhododendron* "abounds on every mountain from Mason and Dixon's line to North Georgia that has a rocky branch." Specimens of this wood submitted to Mr. Scott was so badly selected and seasoned that it was almost impossible to give it a trial. In consideration of its hardness and apparent good qualities, further experiments should be made with it.

16. *Rhododendron californicum.* — Likewise a North American species, the wood of which is similar to the last named. Specimens were sent to Kew by Professor Sargent for report in 1882, but was so badly seasoned, that no satisfactory opinion could be obtained regarding it.

17. *Kalmia latifolia*, L. (Calico Bush or Ivy Bush of North America).—The wood is hard and dense, and is much used in America for mechanical purposes. It has been recommended as a substitute for boxwood for engraving, and trials should, therefore, be made with it.

Natural Order Epacrideæ.

18. *Monotoca elliptica*, R. Br.—A tall shrub or tree 20 or 30 feet high, native of Queensland, New South Wales, Victoria, and Tasmania. The wood has been experimented upon in this country, and though to all appearances it is an excellent wood, yet Mr. Worthington Smith reported upon it as having a bad surface, and readily breaking away so that the cuts require much retouching after engraving.

Natural Order Ebenaceæ.

19. *Diospyros texana.*—A North American tree, of the wood of which Professor Sargent speaks favourably. "It is, however," he says, "in Texas at least, rather small, scarcely six inches in diameter, and not very common. In Northern Mexico it is said to grow much larger, and could probably be obtained with some trouble in sufficient quantities to become an article of commerce." Of this wood Mr. Scott says, "it is sufficiently good as regards the grain, but the specimen sent for trial was much too small for practical purposes." Mr. R. H. Keene, the engraver, says it "is nearly equal to the best box."

20. *Diospyros virginiana*, L. (the Persimmon of America).—A good-sized tree, widely diffused, and common in some districts. The wood is of a very dark colour, hard, and of a fairly close grain. It has been used in America for engraving, but so far as I am aware, has not been tried in this country. It has, however, been lately introduced for making shuttles.

21. *Diospyros ebenum*, Kœnig (Ebony).—A wood so well known as to need no description. It has been tried for engraving by Mr. Worthington Smith, who considers it nearly as good as box.

Natural Order Apocyneæ.

22. *Hunteria zeylanica*, Gard.—A small tree, common in the warmer parts of Ceylon. This is a very hard and compact wood, and is used for engraving purposes in Ceylon, where it is said, by residents, to come nearer to box than any other wood known. On this wood Mr. Worthington Smith gave a very favonrable opinion, but it is doubtful whether it would ever be brought from Ceylon in sufficient quantities to meet a demand.

Natural Order Bignoniaceæ.

23. *Tecoma pentaphylla*, Dl.—A moderate-sized tree, native of the West Indies and Brazil. The wood is compact, very fine, and even grained, and much resembles box in general appearance. Blocks for engraving have been prepared from it by Mr. R. J. Scott, who reported upon it as follows:—"It is the only likely successor to box that I have yet seen, but it is not embraced as a deliverer should be, but its time may not be far off."

Natural Order Corylaceæ.

24. *Carpinus Betulus*, L. (Hornbeam).—A tree from 20 to 70 feet high, with a trunk sometimes 10 feet in girth, indigenous in the southern counties of England. The wood is very tough, heavy, and close grained. It is largely used in France for handles for agricultural and mining implements, and of late years has been much used in this country for lasts. The wood of large growth is apt to become shaky, and it is consequently not used as a building wood. It is said to have been used as a substitute for box in engraving, but with what success does not appear.

25. *Ostrya virginica*, Willd (Ironwood, or American Hornbeam).—A moderate sized tree, widely spread over North America. The wood is light-coloured, and extremely hard and heavy; hence the name of ironwood. It is used in America by turners, as well as for mill cogs, &c, and has been suggested as a substitute for boxwood for engraving, though no actual trials, so far as I am aware, have been made with it.

Besides the foregoing list of woods, there are others that have been occasionally used for posters and the coarser kinds of engraving, such, for instance, as lime, sycamore, yew, beech, and even pine; and in America, *Vaccinium arboreum*, and *Azalea nudiflora.* Of these, however, but little is known as to their value.

It will be noticed that in those woods that have passed through the engraver's hands, some which promised best, so far as their texture or grain is concerned, have been tried upon very imperfect or badly seasoned samples.

The subject is one of so much importance, as was pointed out at the commencement of this paper, that a thoroughly organised series of experiments should be undertaken upon carefully seasoned and properly prepared woods, not only of those mentioned in the preceding list, but also of any others

that may suggest themselves as being suitable. It must, moreover, always be borne in mind that the questions of price, and the considerations of supply and demand, must, to a great extent, regulate the adaptation of any particular wood.

With regard to those woods referred to as being tried by Mr. Worthington Smith, he remarks in his report that any of them would be useful for some classes of work, if they could be imported, prepared, and sold for a farthing, or less than a halfpenny, per square inch.

Specimens of all the woods here enumerated are contained in the Kew Museum.

COMMERCIAL AND MEDICINAL PLANTS OF MEXICO.

In a report issued by the United States Department of Agriculture, giving a review of the agricultural products and resources of Mexico, it is stated that in that country there are to be found 110 medicinal plants known to the physician, 12 varieties of well-known dye woods, many plants used for the same purposes, 8 varieties of important gum trees, and several of the resiniferous trees. Of the whole of the commercial plants, the vanilla, a parasite plant, is of the largest importance. This plant is of the orchid species, indigenous to Lower Mexico and Central America. It is planted from sprouts, and will become fruit-bearing at the end of three years, lasting from thirty to forty years. The capsule of the *Vanilla plantifolia* and *claviculata* is remarkable for its delicate and agreeable odour, and the volatile oil extracted from it. The several varieties of this plant are successfully cultivated in the States of Tamaulipas, Vera Cruz, Tabasco, Oajaca, Chiapa, Guerrero, Michoacan, Colima, Jalisco, and Hidalgo. Anil, the *Indigo-fera tinctoria* of the botanist, is extensively cultivated, and it is stated that indigo has long been one of the exports of Mexico. The following is a description of the manner in which it is cultivated. The old-fashioned crooked stick and oxen are used to plough the fields, and the regular corn crop is planted during June and July. When the corn is about ten inches high, and the soil has been raised into hillocks, the indigo seed is scattered broadcast over the same field, and this is all that is done. The rains beat down the seed sufficiently, and in about one week the young plant appears. The average quantity of seed required is about 100 lbs. per acre. In the month of November the corn crop is harvested, and the indigo plant is then three feet high, and very hardy. About September of the second year the plant is about eight or ten feet high, of proportionate thickness, and of a dark green colour, and it is then cut and pressed. To insure a large proportion of indigo pulp it is important that the plant be cut and placed in a tank at night, or at least before the sun has gained full force. The tanks should also be well shielded from the sunlight, as a strong light bearing on them during the operation materially lessens the quantity of pulp. The pressing tanks are three in number, built of stone and mortar, and are so arranged that the contents of one can be readily drawn into the other. The plant is laid in the first tank, filling it two thirds, and after being pressed with heavy stones, the tank is filled with clear water. After a fermentation of about ten hours the liquid is run off into the second tank, with wooden hand-paddles for from two to four hours. It is then allowed a certain time for settling, and is then drawn off into a third tank. The water, after three or four hours, is then drawn off, and at the bottom of the tank is left a blue pulp, which is taken out, dried in the sun, and packed for shipment. There are many well-known dye woods and plants indigenous to Mexico, which are mostly found in the Tierra Calientes, and embrace, among others, the Brazil tree, logwood, and the Campeche, so named after the State in which it grows. The dye trees of the Tierra Calientes include the *achiote*, or heart-leaved lixa or anotta, the *tintaron*, which yields a beautiful sky blue dye, and the *gengiblillo*, yielding a strong bright yellow. Among the most numerous trees are several varieties of gum and india-rubber trees, cork trees, and dragon root, which latter in Chiapa grows to a medium-sized tree. Palm trees are abundant in many districts, and a large industry exists in the manufacture of palm leaf hats, fine mats, and other articles of use and luxury. One variety of the palm tree, known as the *corozo*, yields an excellent oil. Other trees of the soap plant species furnish an excellent substitute for soap, and a root of the orchid plant, called *yaxte* in the aboriginal dialect, furnishes a very fine soap highly valued for cosmetic purposes. The castor bean is very largely grown, and the expenses of its cultivation are very small. It is estimated that an acre can be planted with 600 trees, yielding at once at least 3,600 pounds of beans, which if pressed as soon as gathered, will return 50 per cent. or 1,800 pounds of oil. The castor plant thrives best under conditions similar to those of coffee growing. When a year old the plant reaches a height of 9 feet, with heavy foliage. The cultivation requires no more care than the corn crop, and its first yield, which subsequently increases yearly, is about six pounds. The production continues during five or even six months of the year, and it is stated that plants from two to three years old yield from five to six pounds every month, or an average of twenty-five pounds per annum for each plant. Another product which is used in Mexico and shipped to France for tanning purposes is the *Cascalotte* bean. This tree grows wild, reaches a height of about 25 feet, and has branching foliage often 30 feet in diameter. It produces in large quantities a bean of a broad and crooked shape. The bean dropping to the ground when ripe is gathered, dried, and pulverised, and in this form makes one of the best of all tanning substances. The tree is found in the States of Michoacan, Coltma, and Guerrero; it grows wild,

and one labourer can pick as much as 250 lbs. of beans a day. Among other useful and medicinal plants may be found the sarsaparilla, *tominogua*, a native cure for fever, the *barba de chibato*, or buck-beard, the *quaco*, the *paroqui*, and *chapi*, herbs used by the Indians to produce perspiration. The *jaljacote*, a species of guava, or South American pear tree, is used for curing skin diseases. Sassafras is abundant, as also the soap wort, or jabonera. The dragon tree is valuable for its medicinal resin or gum. The saffron, cinchona, aloe, many varieties of the acacia, corianda, wild liquorice, and many other useful plants, shrubs, and herbs are found. The leguminous plants are numerous and valuable, and varieties of the *Euphorbiacæ* family are found in abundance along the table lands of the lower Pacific States. It is stated that all the plants now cultivated in Mexico were known to both the Aztecs and their Spanish conquerors, and though the exportation of the plants and their products was at one time much larger than at present, there is every probability with the present and growing activity felt throughout Mexico, that a large increase in production will soon take place.

General Notes.

THE MOON'S ORBIT.—A model of the "Moon's Compound Orbit" is now being exhibited by Mr. John Harris, in the Reading-room of the Society of Arts, and can be seen by members each weekday from 10 to 4 (Saturday, 10 to 2) until the 24th inst. The arch of the model is 24 feet in length, and represents about one-twelfth of the orbital circle of the earth's annual revolution round the sun, or equal to about 30 degrees of that circle. Mr. Harris will attend on Monday and Tuesday, 20th and 21st inst., between two and four o'clock, to explain the model.

NEW BRANCHES OF INDUSTRY IN SWITZERLAND.—An important competition organised in connection with the Zurich Exhibition of 1883, has lately been decided. Herr Schindler-Escher, of Zurich, had given a sum of £140 for the best essay on the above subject. The committee entrusted with the decision has awarded the first prize to Herr Boos, the principal of the School of Art, at Riesbach, near Zurich. Several other works of relative excellence were sent in, one of them embodying a suggestion for introducing the wearing of combed-wool goods in Switzerland.

INDUSTRIAL LABORATORY AT NAPLES. — A laboratory has lately been established at Naples at a cost of £400, of which £240 was granted by the Government, and the remainder furnished by the provincial administration, the municipality and chamber of commerce of that city, for the purpose of affording both practical and theoretical instruction to those engaged in the various branches of the leather trade, and more particularly to the manufacture of gloves, for which Naples has always been famous. Experiments and investigations are made at this laboratory on the payment of a fee, on behalf of manufacturers and others, in all processes relating to the tanning and dying of leather, analysis of tanning and dying materials, &c.

MEETINGS OF THE SOCIETY.

APRIL 22.—"Technical Education, with Reference to the Apprenticeship System." By HENRY CUNYNGHAME. Sir BERNHARD SAMUELSON, Bart., M.P., will preside.

APRIL 29.—"Researches on Silk Fibre." By THOMAS WARDLE.

MAY 6.—

MAY 13.—"A Marine Laboratory as a Means of Improving Sea Fisheries." By Professor E. RAY LANKESTER, M.A., F.R.S.

MAY 20.—"The American Oil and Gas-fields." By Professor JAMES DEWAR, F.R.S.

INDIAN SECTION.

Friday evenings at Eight o'clock.

APRIL 17.—"The Parsis and the Trade of Western India." By JEHANGEER DOSABHOY FRAMJEE. Field-Marshal LORD NAPIER OF MAGDALA, G.C.B., G.C.S.I., will preside.

MAY 8.—"The Ancient and Modern Methods of Treating Epidemics of Small-pox in India." By ROBERT PRINGLE, late Sanitary Department H.M. Bengal Army. Sir PHILIP CUNLIFFE-OWEN, K.C.M.G., C.B., C.I.E., will preside.

MAY 15.—"The Golden Road to South-Western China." By R. K. DOUGLAS, Professor of Chinese at King's College, London. The Hon EDWARD STANHOPE, M.P., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings at Eight o'clock.

APRIL 28.—"The Federation of the Empire." By J. E. GORST, M.P. The Right Hon. W. E. FORSTER, M.P., will preside.

MAY 19.—"New Britain and the Adjacent Islands." By WILFRED POWELL. Sir FRANCIS DILLON BELL, K.C.M.G., will preside.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings at Eight o'clock.

APRIL 23.—"The Chemistry of Ensilage." By FREDERICK J. LLOYDD. Lord THURLOW will preside.

The dates given above are subject to alteration.

Cantor Lectures.

Monday Evenings at Eight o'clock.

The Sixth Course, "Photography and the Spectroscope." By Captain C. W. de W. Abney, R.E., F.R.S.

Lecture I. April 20.—The prismatic spectrum and influence of the material on the spectrum. Dispersion and resolving power. Uses of the slit and collimator. The spectroscopic camera. Application of photography for investigating the spectrum, and of the spectrum for investigating photography.

Lecture II. April 27.—The diffraction spectrum. The ordinary grating. Influence of the number of lines on resolving power. The reflection grating. The flat reflection grating. Absorption of radiation and atomic motion, and the formation of the photographic image.

The Seventh and concluding Course, "The Manufacture of Toilet Soaps." By C. R. Alder Wright, D.Sc., F.R.S., F.C.S. May 4, 11, and 18.

Admission to Meetings.

Members have the right of attending all the Society's meetings and lectures. Every member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the members, but admission can also be obtained on the personal introduction of a member.

MEETINGS FOR THE ENSUING WEEK.

Monday, April 20...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Captain C. W. De W. Abney, "Photography and the Spectroscope." (Lecture I.)

Invention Institute, Lonsdale-chambers, Chancery-lane, W.C., 8 p.m. "Further Discussion on the Patent-law of 1883."

Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. A. J. Burrows, "Romney Marsh, Past and Present: a Sketch of the Reclamation of this and adjoining Marshes."

British Architects, 9, Conduit-street, W., 8 p.m. Mr. F. T. Baggallay, "Some Notes on Flintwork."

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m. The Rev. Prof. Beal, "The Age and Writings of Nagarjuna Boddhisattoa (from the Chinese.)"

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Paper by the Rev. R. Collins.

Tuesday, April 21...Royal Institution, Albemarle-street, W., 8 p.m. Prof. Gamgee, "Digestion and Nutrition." (Lecture VI.)

Civil Engineers, 25, Great George street, S.W., 8 p.m. 1. Discussion on Mr. W. Shelford's paper, "Non-tidal Rivers." 2. Prof. Hele Shaw, "Mechanical Integrators."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m. Mr. E. W. Brabrook, "The Relation of the State to Thrift: Ten Years' Statistics of Friendly Societies and similar Institutions."

Pathological, 53, Berners-st., Oxford-st., W., 8½ p.m.

Zoological, 11, Hanover square, W, 8½ p.m. 1. Sir Richard Owen, "The Structure of the Heart in *Ornithorhyncus* and *Apteryx*." 2. Mr. Oldfield Thomas, "Notes on the Characters of the different Races of *Echidna*." 3. Dr. Mivart, "The Anatomy, Classification, and Distribution of Arctoidæ." 4. M. Jean Stolzmann, "Observations on the Theory of Sexual Dimorphism."

Wednesday, April 22...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Henry Cunynghame, "Technical Education, with Reference to the Apprenticeship System."

Microscopical, King's College, W.C., 8 p.m. Conversazione.

Royal Society of Literature, 4, St. Martin's-place, W.C., 4 p m. Anniversary.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7½ p.m. Mr. T. M. Rymer Jones, "Methods for Rendering Wood for Building Purposes Non-inflammable."

Thursday, April 23...SOCIETY OF ARTS, John-street, Adelphi, W C., 8 p.m. (Applied Chemistry and Physics Section.) Mr. Frederick J. Lloydd, "The Chemistry of Ensilage."

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 2 p.m. Annual Meeting.

Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Mrs. Sheil, "Physiology and the Laws of Health." (Lecture VIII.) "Food."

Parkes Museum of Hygiene, 74A, Margaret-street, W., 8 p.m. Sir Spencer Wells, "Cremation."

Royal Institution, Albemarle-street, W., 8 p.m. Prof. Tyndall, "Natural Sources and Energies." (Lecture II.)

Telegraph-Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. 1. Discussion on Professor Oliver Lodge's paper, "The Seat of Electromotive Force in a Voltaic Cell." 2. Mr. Andrew Jamieson, "Electrical Definitions, Nomenclature, and Notation."

Friday, April 24...United Service Institution, Whitehall-yard, S.W., 3 p.m. Sir William Smart, "The Native Tribes of the Soudan."

Royal Institution, Albemarle street, W., 8 p.m. Weekly Meeting, 9 p.m. Mr. W. Carruthers, "British Fossil Cycads."

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. John M. Davies, "Heat Engines."

Quekett Microscopical Club, University College, W., 8 p.m. Papers by Dr. Burch and Mr. F. Cheshire.

Browning, University College, W.C, 8 p.m. 1. Dr. Berdoe, "Browning as a Scientific Poet." 2. Paper by Mr. J. J. Rossiter.

Saturday, April 25...Geologists' Association, 2 p m. Visit to the Zoological-gardens, Regent's-park. 3.30 p m., Demonstration at the Kangaroo Sheds, by Dr. P. L. Sclater, "*Marsupials* and *Edentates*, and their Relation to Extinct Forms."

Royal Institution, Albemarle-street, W., 3 p.m. Mr. W. Carruthers, "Fir Trees and their Allies." (Lecture I.)

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p m.

Physical, Science Schools, South Kensington, S.W., 1. Lord Rayleigh, "The Theory of Illumination in a Fog." 2. Prof. A. W. Rücker, "Compound Dynamo Machines." 3. Mr. J. W. Clarke, "The Determination of the Heat Capacity of a Thermometer."

Journal of the Society of Arts.

No. 1,692. Vol. XXXIII.

FRIDAY, APRIL 24, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

PROFESSOR VAMBERY'S LECTURE.

Professor Vambéry will deliver a lecture on "Herat," before the Indian Section of the Society of Arts, on Friday evening, May 1st, at eight o'clock.

For the convenience of those members who wish to be present, the usual rules for the admission of members and their friends will be suspended. Admission will be by ticket only, and no person, whether a member or not, can be admitted without a ticket. A sufficient number of tickets to fill the room will be issued to members in the order in which they apply, until the number is exhausted. Each ticket will admit one person, and is transferable. Not more than a single ticket can be issued to any member.

INTERNATIONAL INVENTIONS EXHIBITION SEASON TICKETS.

The Executive Council of the International Inventions Exhibition have consented to allow Members of the Society of Arts the privilege of purchasing Season Tickets for the Exhibition at half-price (10s. 6d.) Any member desiring to avail himself of the privilege can obtain a ticket by applying to the Secretary, and remitting the price, 10s. 6d. Each member will only be allowed the privilege of purchasing a single ticket on these terms, which will be a personal admission, not transferable. It will be understood that all applications must be accompanied by the above-named remittance, and that tickets at the reduced rate can only be obtained from the Secretary of the Society.

Season tickets admit to the opening ceremony on Monday, 4th May.

CANTOR LECTURES.

Captain C. W. de W. Abney, R.E., F.R.S., delivered the first lecture of his course on "Photography and the Spectroscope," on Monday evening, 20th inst.

The lectures will be published in the *Journal* during the summer recess.

PRACTICAL EXAMINATION IN VOCAL AND INSTRUMENTAL MUSIC.

The next Examination in London will be held by Mr. W. A Barrett, Mus.Bac. (Oxon.), at the House of the Society of Arts, 18, John-street, Adelphi, W.C., during the week commencing 8th June, 1885.

Full particulars can be obtained on application to the Secretary.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, April 14, 1885; Hyde Clarke in the chair.

The paper read was—

BRITISH INTERESTS IN EASTERN EQUATORIAL AFRICA, MORE ESPECIALLY IN THE KILIMA-NJARO DISTRICT AND ON THE VICTORIA NYANZA.

By H. H. Johnston.

The impressions made on me by my recent sojourn on Mount Kilima-njaro, and in its vicinity, are so vivid in their character, that I fear to many whom I am addressing to-night my descriptions of the country may seem somewhat exuberant, but I speak to you confidently, for I know that, sooner or later, others who follow in my footsteps will substantiate my reports.

Let me first briefly summarise the object of the present paper. It is to bring to your

notice a vast and richly endowed district of Eastern Equatorial Africa, where at present no white man resides, to show you how well worthy it is of being opened up to commerce and civilisation, and, further, to give you some notion of how this might most profitably be done. I shall also briefly touch on three important ends to be attained by British enterprise in this part of Africa, viz., the discovery of a new and unoccupied field for our commerce; the suppression of the slave trade; and the bringing civilisation to many tribes who are willing and worthy to receive it.

Firstly, as to the physical geography of this country, which I have broadly described as Eastern Equatorial Africa. For present purposes, it may be delineated as follows:—By the River Ruvu, or Pangani, on the south; then westwards, following the 4th degree of South Latitude to the 32nd degree of East Longitude, including the basin of the Victoria Nyanza lake, and round again to the east, from the northern border of the lake, by Baringo, to Kenia, the Pokomo river, and the coast.

The most marked characteristics of this region are its immense isolated mountain masses, in most cases volcanic, such as Kenia and Kilima-njaro, the latter the highest known peak in Africa, its spacious level plains, or, more strictly speaking, plateaux, and its freedom from marshy or swampy ground, as contrasted with other parts of Africa. The water supply is fairly abundant, and equally distributed, though there is but one river, the Tana, or Pokomo, which is at all navigable. Besides the huge Victoria Nyanza, there are a few very much smaller lakes, one or two of which are salt, and the majority fresh. The highlands, up to 10,000 feet, and also the banks and rivers of streams, are generally clothed with forests of splendid timber, the plateaux are often covered with scattered bush and short grass—not the terrible giant grass of six to eight feet high, which obstructs so much of African country; while many districts I can only compare to beautiful natural lawns, whereon you meet with springy turf, closely cropped by the browsing antelopes, and here and there a group of handsome shady trees, disposed with so much regularity that it would seem as if man and not Nature had planted them. Such is the country that lies between Pare and Usambara, or in the vicinity of Lake Jipe, or again, to the south of Kilima-njaro, and also in many districts to the north, as we hear from Thomson.

These vast regions are very unequally populated. On the coast there is a fringe of slightly civilised races, nominally under the dominion of the Sayyid (or "Sultan" as we incorrectly call him—he is only known by his subjects as "Sayyid" or "Lord") of Zanzibar. These people belong principally to the Bantu family of negroes, which includes all the inhabitants of Africa from the Victoria Nyanza to the Cape and Fernando Po to Mombesa, with very few exceptions. There are also Gallars on the North between the Sabaki and the Dana rivers, a few invading Somalis in the same district, Arabs of pure blood and Arab hybrids of every degree throughout the length of the littoral, and about four thousand Banyans and other natives of British India who come there to trade and sometimes to settle. To add to this medley of races, there are remains here and there of ancient Persian and Portuguese colonisation, but, as I have before said, the bulk of the coast population is Bantu-negro, a stock which seems to absorb and assimilate easily most foreign strains. The lingua-franca spoken is the celebrated Swahili language, one of the Bantu tongues which promises to be the French of Eastern Africa.

On penetrating inland from the coast, the country is for the first hundred miles, as a rule, very thinly inhabited, except on certain mountainous districts, or along the coast of the Ruvu, the Sabaki, or the Dana rivers, and what people there are belong to the Bantu stock, and speak languages related to Swahili. Whenever you meet with people speaking Bantu languages in this part of Africa, you find they are invariably settled agriculturists, and never nomads. As a contrast to them, may now be mentioned the celebrated Masai, a negroid race of splendid physical development, speaking a most interesting language which is distinctly related, I fancy, to the Galla tongues. The Masai are semi-nomads, that is to say, that each tribe has its home country wherein the married men and women settle, and move about within a circumscribed radius, while the warriors, who are forced to remain unmarried, range over immense areas, for the sake of plunder. These people were once, and are still in a lesser way, the scourge of Eastern Equatorial Africa. They have made previously well populated prosperous districts abandoned wildernesses, driving away all the cattle, killing such of the inhabitants as resisted, and leaving the remainder to die of starvation. But of late years they no longer

play the same havoc. Between the coast and Kilima-njaro they are rarely to be met with, and in such cases as when they are encountered away from their homes, the white traveller will not find them very hard to deal with. Commerce is slowly but surely humanising the Masai. They most of them prefer trading to fighting now. Yearly they are visited by many native caravans from the coast, who go to buy ivory with iron, wire, cloth, and beads. Certain tribes of the Masai, generally known as Wa-Kwavi by the coast people, have abandoned entirely this roving robber life, and now occupy large districts as quiet, thrifty agriculturists. The Masai are all of them great cattle keepers, and possess not only innumerable herds of splendid kind, but also keep numbers of donkeys as beasts of burden. These asses are very fine animals, resembling exactly the Ethiopean wild ass, from which stock they are certainly derived. The Masai are a people who in time will become amenable to civilisation, I am sure, and commerce will temper their wild ways. They are very different from the mad fanatics we are slaughtering in the Soudan, and if all Europeans will behave as well to them as your distinguished countryman, Mr. Thomson, has done, we shall soon be welcomed as traders and settlers in their midst.

It may be roughly said, then, that between the coast and the Victoria Nyanza, the plains or plateaux are inhabited by the Masai and their helot races, and the mountains and mountain ranges by Bantu people. These latter evidently occupied the land prior to the incursion of the Masai from the north, and existed in former times in greater numbers than at the present day. Of late, however, their fortunes have begun to revive. Forced, during their struggle for existence, to take to the highlands that were difficult of access to an invader, they have become a more hardy, independent race than their relations on the coast, and have also, in their wish to turn their mountain soil to the best advantage, become skilful and laborious agriculturists. Now their relations with the Masai are becoming sensibly improved, the Masai raids have ceased before the rude fortifications of the hill tribes, and both parties are able to trade on equal terms. The inhabitants of the mountains bring their honey and vegetables, their smiths' work, and dressed skins, and exchange them against the ivory, rhinoceros horns, and natron salt that are collected by the rovers of the plains. These two distinct races, whose contact was formerly so provocative of bloodshed and rapine, are now exchanging peaceably their products, but also their ideas, manners, and customs. The Bantu of Kilima-njaro and Taveia loves to copy the Masai costume and mode of fighting, he incorporates many Masai words and salutations into his own tongue, while the once nomadic and restless Masai are increasingly taking to agriculture in the vicinity of Bantu settlements, and are changing from lawless robbers into quiet and honest tillers of the soil.

Around the Victoria Nyanza lake, the population becomes very dense, and probably the littoral people alone may be estimated at from ten to twelve millions. With one small exception, they are Bantu, and speak languages of an archaic form, and more resembling the typical Bantu mother-speech than any other we have yet met with. The exception is a small enclosure of Nilotic negroes settled in the country of Kavirondo on the eastern shore of the lake, who have never yet come into contact with Europeans. We know something of their language from the Swahili traders, and we find it to belong to the same group as the Shilluk of the White Nile.

Besides the races above enumerated, dwarf tribes are reported in the unknown country lying between the Victoria Nyanza and Kilima-njaro, and there are also curious helot tribes dwelling among the Masai as hunters or smiths or slaves, who speak languages of their own, and remain at present unclassified in their affinities.

Of all the people I have mentioned in this hasty description, the Bantu offers the greatest hope for civilisation. He is so industrious, so imitative, so inquiring, that he is instinctively attracted towards the white man. He is a born trader, and will travel miles to sell a fowl, while his appreciation of Manchester stuffs and Birmingham beads should ensure him the favour of British merchants.

The animal and vegetable products of this vast region are typically African. I might mention, to begin with, that it is a sportsman's paradise. Such quantities of big game were surely never met with elsewhere. If you want confirmation of my statements on this point, read Mr. Thomson's book, "Masai-land." In some districts we may stand on a hillock and see the plains at your feet covered with compact herds of antelopes, moving in squadrons, with straggling companies of

giraffes, with scattered flocks of ostriches. Buffaloes abound so as to be dangerous. Rhinoceroses are so numerous that their horns are an important item in the trade, for they may be bought in the interior for a few pence worth of cloth, and sold on the coast for three and four rupees each. Hippopotami are abundant in the rivers and lakes. The Vice-Consul at Lamu, on the coast near the Pokomo river, informs me that when properly prepared (which is done by cutting the skin into long thin strips and drying it in the sun), hippopotamus hides will fetch £5 a-piece in Natal. But the great wealth of this country lies in its ivory, which is preferred to any other in the Zanzibar market. The elephant abounds in the neighbourhood of Kilima-njaro to the extent of many thousands. He here becomes quite a mountaineer, and ranges through the magnificent forests that clothe the upper slopes of this giant among African peaks. The natives waylay his forest tracks with artfully devised pitfalls and traps, preferring this more cowardly way of procuring their ivory to facing the elephant in the chase. Other tribes to the north and west of Kilima-njaro kill the elephant with poisoned arrows, or javelins, or sharp swords. But in one way or another they procure ivory to supply the many native caravans led by Moslem natives from the coast, which annually traverse this country between the Indian Ocean and the Victoria Nyanza lake. Another item of trade should not be forgotten, namely, the valuable and handsome wild beast skins, which may either be procured in the chase, or very cheaply purchased from the natives. A leopard skin may be bought for about two or three shillings' worth of goods, and will sell on the coast for eight or nine. Lions' skins are less easy to obtain from the natives, as that animal is rarely killed by them, but European sportsmen might shoot him to any extent, as he is both common and bold. Monkey skins, of the handsome variety of white-tailed colobus, which is alone found in this region, are valuable, and fetch a good price on the coast.

Ostriches are exceedingly numerous in the vicinity of Kilima-njaro. When living at Taveita in the month of August last, I and my men used to largely subsist on their eggs, which were brought us in numbers by the natives, and sold for about a pennyworth of cloth each. Sometimes by searching we would ourselves discover nests. In the month of October I bought twelve young ostriches from the natives at the rate of an ell of cloth apiece. I could have purchased many more, and started an ostrich farm had I wished, but as I was returning shortly to the coast I did not feel disposed to commence the undertaking. I tried to bring these young ostriches away with me, but they all died before reaching Zanzibar, as they suffered a great deal from the effects of the land transit, being very young. Of course to any ornithologist this country is exceedingly interesting, but to those whom I am addressing to-night, rare or beautiful birds will not serve as a sufficient inducement for opening up a new country; still I might remark, for economic reasons, that there are abundance of guinea fowl, francolin, pigeons, and bustards, and all these serve materially to supply the traveller with palatable food.

I cannot say much for the reptiles of this country, as there are few species which would attract the traveller's attention, and none which, as far as I know, would be useful commercially, unless the crocodiles of Lake Jipe might furnish some of the leather which is now so fashionable for dressing-bags; but the very scarcity and unobtrusiveness of the reptiles is a negative advantage. Like most parts of Africa I have ever visited, the snakes here are very few and infrequent in their appearance. Most species, too, are non-venomous.

In many of the streams, rivers, and lakes there are fish in great quantities, representing most of the African freshwater genera. There are few that are not edible, and some species are remarkably good to eat, and of considerable size and weight. While at Taveita I was often able to feed the entire caravan during a week or more on the fish caught in the small River Lum; and at Jipe they are so plentiful that a fish-smoking establishment, similar to those on the Upper Congo, might be set going to provide food for long journeys. There are few things that Swahili porters like better than a fish diet.

The insects are not likely to offer anything commercially interesting, nor indeed any of the lower invertebrate forms. I might, however, in their case lay stress on the same favourable fact as with regard to the snakes, viz., the scarcity or absence of noxious forms. Thus there is no tsetse fly, such as, but a short distance southward, interferes with the introduction of horses and cattle. Mosquitoes only exist in certain districts, near rivers or lakes, and are entirely absent from most parts of the

country. Fleas and bed bugs are unknown, nor has the American jigger, which is such a pest on the Congo, been introduced. White ants are not very numerous, and do not exist at all above a moderate elevation. The tœnia intestinal worm, so often heard of in other parts of Africa, is here never to my knowledge met with.

I might mention that a small edible freshwater crab is found in the rivers.

As to the vegetable productions they are, apart from those cultivated and introduced by man, certainly valuable. There is particularly fine timber growing in many parts, particularly on Kilima-njaro and in the mountainous districts to the northward, and again on the west of the Victoria Nyanza. The forests in Usambara and in Pare, both districts near the coast, are full of magnificent lofty trees, which are much prized at Zanzibar for shipbuilding. On the coast and in Zanzibar, timber sells for 25 to 50 dollars per 50 cubic feet, according to quality.

Gums are produced in the interior, both copal and a kind called false copal. India-rubber can be procured from at least one creeper, the *Landolphia florida*, and I think also another, a species of fig. Coffee grows wild, especially on the northwards of the district, where it is the same species as the Abyssinian plant, which, it is supposed, being first introduced from the kingdom of Kaffa to the south of Abyssinia, thence derives its name. Coffee planting would succeed admirably in districts like Usambara, which may be regarded as the natural home of this shrub, which is, indeed, indigenous to the African continent. I might mention that cardamums are produced here, and semsem seed is also largely reported for making spurious olive oil.

On the trees growing in the Kilima-njaro and Usambara forests, orchilla weed, in incredible quantities, is found growing. When delivered half clean, that is to say, mixed with sticks and rubbish, on the coast, it fetches from 3 to 3½ dollars per frasilah of 35 lb.

As regards minerals, iron ore is found in some abundance, and copper apparently also; since the natives possess rude rings and ornaments of this metal which have not come from the coast. Nitrate of soda covers vast plains to the south, west, and north of Kilima-njaro.

There is good building stone in many parts of the country. Limestone often appears.

And now, having briefly noted some of the productions with which this part of Africa is naturally endowed, I may mention others which owe their introduction or development to the agency of man.

Vast herds of cattle are kept not only by the Masai, whose very *raison d'être*, as it were, consists in cattle breeding, but also by the agricultural races on the borders of Lake Victoria Nyanza, and in the mountain districts everywhere. When I was residing on Kilima-njaro I not only purchased excellent beef at about 10s. a bullock, but also procured daily so much milk that I was able to make cream, butter, and cheese in plenty. The oxen are not, as a rule, so large as the Cape breeds, and, indeed, come from quite another stock, being descendants of Asiatic humped variety—the zebu—introduced into Africa by the ancient Egyptians. The hides are held in such little account by the natives that they may be purchased for the merest trifle. As I have already mentioned, the Masai keep large herds of fine strong asses, which they are always ready to sell cheaply.

Goats and sheep are most abundant. The goats are small, plump, and great milk-givers. The sheep belong to the fat-tailed variety, and offer really excellent juicy tender mutton. Those who have visited Usambara will agree with me that the mountain mutton of East Africa rivals in tenderness and shortness that furnished by the Welsh and Highland sheep. Like all African sheep, they are hairy and without wool. Fowls are not kept by the Masai, but are met with in great quantities on Victoria Nyanza, and among all of the agricultural Bantu races. On Kilima-njaro they might be purchased at the rate of one ell of cloth each, averaging a cost, when the local value of cloth is estimated, of 2½d. each. In two days, at Mandara's capital, I purchased eighty fowls. Some of them are a very handsome breed, pure white, with very long tail feathers in the male. Another variety is plump and dumpy, with exceedingly short legs. The hens are very good layers.

The vegetable productions of the natives' cultivation are the banana, the sweet potato, the edible arum root, the sugar cane, Indian corn, *mtama*, or red millet, and many unnamed varieties of peas and beans.

A little rice is grown in some districts, namely, at Taveita and on the River Dana. Tobacco is everywhere abundant, and exceedingly cheap.

I might mention my own almost incredible experience with the cultivation of European vegetables on Kilima-njaro. Immediately after my arrival, I planted the eyes of a few potatoes,

onion bulbs, and the seeds of mustard, cress, radishes, turnips, carrots, peas, beans, spinach, horage, sage, tomatoes, cucumbers, and melons. Everything came up and flourished amazingly. In three months time, I had a dozen fine cucumbers from one plant, and so many potatoes that I was able to give them away to my men, as well as supplying my own table. I had everything else in abundance in a short space of time. Before leaving, I had planted my land at Taveita with wheat and coffee, limes, oranges, mangoes, and cocoanuts. I also distributed numbers of useful seeds among the natives.

I should have mentioned in its proper place before the vegetables, that there is a great quantity of delicious honey produced throughout this district. The wax is of very good quality, but the natives have no use for it, and merely throw it away.

I might now, perhaps, briefly summarise the principal trade products, and in some cases, give their cost in the interior and on the coast. At present, no doubt, the most paying thing is ivory. This may be bought in the Masai countries, between the Victoria Nyanza and the coast, at the rate of from one to two shillings a pound, according to quality. When I refer to money in the interior, I mean money's worth in cloth or other trade goods. On the coast, ivory sells at from six to ten shillings a pound, sometimes reaching a higher price.

Hides may be almost got for nothing in the interior, and merely cost the expense of transit. On the coast they are sold, when dry, at about 1 dollar for 7 lbs.

Rhinoceros horns I have already alluded to. They find a ready sale on the coast, fetching on an average, 5s. a-piece.

Live stock of all kinds may be purchased cheaply in the interior, and find a ready market on the coast.

There is even another source of profit in which, although many people laugh when I suggest it I see nothing ridiculous, viz., the capture and sale of wild animals. If it can pay Hamburgh and Austrian firms to hunt, and employ hunters on the confines of Abyssinia, for the purpose of supplying the zoological gardens of the world with wild animals, why should not the same thing be done here, where animal life is present to a degree which puts Abyssinia and the Eastern Soudan to shame. If you can get from £100 to £200 for a young rhinoceros, elephant, hippopotamus, or giraffe, with lesser sums, in proportion, for large antelopes, zebras, buffaloes, ostriches, lions, leopards, snakes, and crocodiles, surely it is worth while to capture them in districts like these, that are actually nearer the sea than the hunting grounds of the German firms, and where the natives are already familiar with such a trade, and with the mode of capturing wild animals alive? When I was on Kilima-njaro and Taveita, the natives were always bringing me live creatures for sale, and I have already mentioned how cheaply I bought young ostriches.

Another important trade product would be orchilla weed, which may be gathered for nothing in the vast forests of Kilima-njaro. I have already mentioned its selling price on the coast.

Iron, copper, and nitrate of soda, might pay profit on their transit, when communications between the coast and interior are facilitated.

Nevertheless, it is to be admitted that the special wealth of this country lies in its agricultural future. There are districts that might become the granaries of the world, possessing, over a large area, a European climate. There are other regions peculiarly adapted by their elevation for the culture of quinine. Sugar-cane already grows half wild, and its cultivation might be increased to any extent. Coffee, tea, cacao, vanilla, would thrive in countries and districts remarkably suitable for their favourable growth. Above all, the question arises that if it can pay people to open up and trade with other parts of Africa, why should these magnificent fertile lands remain untouched, when they possess a climate superior in its salubrity to any other part of the continent?

In the neighbourhood, and near the base of Kilima-njaro, the greatest heat I registered was 81°; in the warmest part of the interior, 91°. The average night temperature in hilly districts is 60°; in the plains, 68°. Except on the loftiest mountains, and on the Victoria Nyanza Lake, where it rains a few days in every month, the seasons in Eastern Equatorial Africa are regular in their divisions of wet and dry. From June to the end of October there is almost no rain, and from November to May there is an abundant rainfall during certain months. On Kilima-njaro the climate up to 8,000 feet is that of a Devonshire summer; above that elevation you may have it as cold as you like, the higher you go.

I hope I have now said sufficient to show you that if Africa is worth opening up at all, the region which lies between the coast and Victoria Nyanza is eminently so. There is no

doubt that Africa is the New World of the nineteenth century. What America was to Europe in the sixteenth and seventeenth centuries, that Africa is now. Within the last two years, England, France, Germany, Portugal, Spain, and Italy, have taken decided steps towards founding African colonies. Consequently I argue from this that if land in Africa is worth having, how much more profitable would it be in a fine country with a healthy climate lying between a great lake and the Indian Ocean.

Having explained to you that from my point of view this region is worth possessing, I now wish to indicate to you as briefly as possible the best way of opening it up to trade and civilisation. Selecting some good port on the coast—and there are three or four to choose from, within a limit of a hundred miles of coast-line—the expedition should establish themselves firstly in the healthy and beautiful country of Usambara. The road to the interior runs either to the north or south of this little Switzerland, and joins to the west of it. In Usambara the first station should be established, as the country is very healthy. Here, too, the land might be sown and planted with all kinds of crop, for the proximity to the sea would render exportation easy and cheap. From Usambara you should cross the rich and fertile valley of the Mkomazi river and enter the hill country of Pare, the trade route continuing along the level plain at the foot of the hills. The scenery of Pare I can only call enchanting. There are wooded crags, waterfalls, secluded Alpine valleys and splendid views. The people are pleasant to deal with, and food is plentiful. From Pare you might proceed to Ugwéno, over against Lake Jipe, the road still following the plains, and the stations being established in the hills. From Ugwéno it is a short distance from Kilima-njaro, which offers splendid sights for large settlements, and has also no scarcity of food. From Kilima-njaro there are two routes to be opened up. One, or the most important, leads past Mount Méru, another pleasant site for a trading station, straight to Speke Gulf, on the Nyanza. The other is more or less Thomson's track, leading to Lake Baringo and the north-west. This is the richest country for ivory. Hither every year come the Swahili caravans, who trade nearly to the borders of Abyssinia and the Nile. In all important districts stations might be founded after Stanley's style along the Congo, and these would, in time, become centres of civilisation, cultivation, and trade. Although there is no doubt that a railway, under British auspices, made to connect the Victoria Nyanza with the coast, would give all the trade of Eastern Central Africa into our hands, yet it seems to me that that is a matter altogether for after consideration. The first thing is to develop trade and create agriculture. Along many of the native tracks, as they at present exist, there is no obstacle for stout waggons, at any rate, as far into the interior as the precincts of Méru and Kilima-njaro, that is to say, half way to the Victoria Nynaza. Mules in plenty may be purchased in Zanzibar, and will do well in the country, or asses might be bought from the Masai. Oxen, doubtless, might also be trained to draw waggons as on the coast. As I have before remarked, there is no tsetse fly in the country, so that even horse breeding might be attempted in time. Human labour is plentiful on the coast and fairly cheap. You may hire good stout carriers at the rate of 5 dollars a month, and the cost of their food is about 2d. a day. Many of these men make very decent soldiers and guards, as Stanley has found on the Congo. As a rule the Zanzibar porters are faithful, trustworthy men—I have always found them so, and have even discovered very fine qualities in their nature too. At any rate, if they fall out with a white man it is generally his fault; a very little discipline, together with a kind and quiet manner, will always keep them in order. Many of them can read and write their own language in the Arabic character, so that if you wish to communicate with them at a distance you can do so by letter. The cost of keeping these men in the country would very much lessen after the first year or two, as you might soon grow sufficient food on your plantations to support the entire expedition. These Zanzibaris are very easily satisfied. They will subsist tranquilly on a few handfuls of maize a day, or a little rice and dried fish, or simply bananas; while if you manage to bring down some zebra or antelope with your rifle they are overjoyed. In two days ten men will construct you a spacious dwelling with a grass-thatched rain-tight roof, and in a much shorter time will build their own simpler habitations. They are singularly handy, and can plant gardens, make roads, trap animals, cure skins, construct bird-cages, wash clothes, mend them, make them, cook a dinner, and arrange a nosegay with equal facility. They are much more ingenious than English navvies, much more enduring of hardships, and much more courteous in behaviour.

Without doubt, they are the means, the force, by which Eastern Africa will be opened up.

The white men who should form the pioneers of any commercial enterprise in Central Africa must be young, vigorous, and active, not, as they are so often, *usé*, battered men, who have failed in other careers, and try Africa as a last chance. They should possess sufficient education to be inspired with an intelligent interest in the wonderful nature that will surround them. There is no more miserable person in Africa than your utterly uncultured man; he pines and sickens for want of sympathy with his surroundings, while he who is so far alive to natural history as to be moved by the interesting fauna and flora of equatorial Africa will never be lonely, or have time to be ill. If any of them have a taste for sport, he will be never unhappy, for this country surely offers, without exception, the most splendid hunting-ground in the world. Nor, in such a case, will his sport be mere useless butchery of beautiful animals. He will be able to supply his caravan with fresh meat, at no expense, and may secure many valuable skins and hides. In the case of elephants, a sportsman is a positive acquisition to the party, as he can procure ivory for nothing. I have, personally, known men in South Western Africa who have made their fortunes over ivory and ostrich feathers.

Any enterprise that has the intention of opening np this part of Africa, should begin modestly, without a large staff of white *employés*, or ambitious plans loudly proclaimed to the world. With care, most, if not all, of the preliminary expenses might be paid with trade profits, and in time, I have no doubt, a handsome surplus might be laid aside. I reckon, that an expedition of this kind, I would suggest, might penetrate some distance inland, create stations, buy ground from the local chiefs, and sink about a thousand pounds in trade goods for about £7,500 the first year, £5,000 the second, and £4,000 the third, while after that time, it should be self-supporting, and be putting aside money to repay the original outlay. This would include the employment and all expenses connected with the employment of four white men, about 200 Swahili porters, labourers, and guards.

In my opening remarks I spoke of opening a new field for British commerce in this region. This I am convinced we should do. Wherever I went in this country the natives were anxious to trade—more anxious to trade than to fight, always. Constantly they have said to me, "Why won't you come here, and set up a shop"—for shop they employ the word *duk*, which the Swahilis have taught them—"and let us exchange our goods for yours?" At places nearly two hundred miles from the coast I have found people, who had never seen a white man before, in the possession of Maria Theresa dollars and Indian rupees, with which they came to buy cloth from me. They had, of course, received this currency from the coast traders, but it only shows they are beginning to understand the value of money; nay more, Mandora, an influential chief on Kilima-njaro, wanted me to open a banking account for him at Zanzibar, and he had a distinct though crude idea of drawing cheques. Even the fiercest people here have wants for extraneous things that must be satisfied. Then again, if you introduce commerce and a ready market, you suppress the slave trade. Chiefs now sell their people into slavery because the Arabs cannot buy anything else; but once convince them—and Africans are much more practical than you think—that more money is to be gained by employing their serfs to cultivate the soil at home and produce food stuffs and other products for sale, and I am sure the expatriation of these wretched people will cease. Again, at the present moment one chief makes war against another to procure prisoners and sell them as slaves, but commercial instinct will introduce peace by turning the sword into a reaping hook, and covering the devastated fields with fair and marketable harvests. These people are well worthy of civilisation—yes, even the fierce and roving Masai, who are already being softened wherever they infringe on the rendezvous of coast trade.

I would suggest that in any undertaking to open up Eastern Equatorial Africa, Kilima-njaro should be made the centre of operations, both by reason of its fine climate and the placability of its inhabitants. I will also mention that the intervening country between Kilima-njaro and the coast is quite safe for travelling.

I have no doubt many here present to-night have heard some of my statements with amused incredulity, and are prepared to hotly contest them. Let me disarm their criticism by assuring them that I have merely related what has come under my personal experience, and so, however much my information may conflict with previous information, I hope they will give me the benefit of the doubt, until some traveller, following in my footsteps (as I followed in

Thomson's) is able to disprove what I say. I would also like to remark that my interest in this country is purely disinterested. I an not an African trader, nor do I intend to be. Scientific pursuits have led me to this richly endowed region, and I have thought it well to let my countrymen know what advantages it possesses, so that, when some day it comes into the hands of Germany or some other European power, and British merchants and philanthropists are bewailing the loss of the great African sanatorium, they cannot at least plead ignorance of its existence or advantages. Having said this much, I leave my poor remarks to the kind consideration of all interested in the Dark Continent which I have sought to serve. I would only ask you one privilege in return for any information I may have been able to impart. Should ever some powerful trading or political association be formed to develop the resources of Eastern Equatorial Africa with Kilima-njaro as their basis, I hope they will accept one fanciful suggestion from me. They will want a distinctive flag to fly from their stations and to precede their trading caravans; let its colours be green, white, and blue; white for the snow, blue for the heavens, and green for the forests of this splendid land.

DISCUSSION.

Archdeacon Farler (of Usambara) said that having lived for ten years in Usambara, he could confirm all that Mr. Johnston had stated about the country. When first he went there the natives were called wild men, and purchases were made by means of strings of beads and cloth; and upon his proceeding to build a stone house, the natives assembled to drive him out of the country, believing that he intended to build a fort to be used for the purpose of conquering them. In a very short time, however, the natives learnt thoroughly to trust white men, and a stone church had lately been erected entirely by native labour. Usambara was a magnificent mountainous country, the mountains ranging from 2,000 ft. to 5,000 ft. in height, with elevated terraces and plateaux, and valleys with streams of water and magnificent trees. Coffee grew wild in various districts, and the country was merely waiting for the planters; in fact, fortunes were waiting for those who chose to dig them out. The climate was very healthy, and not like the swampy places which the Germans had lately taken to. All that one would have to get over in opening this new district would be the fever which, as a rule, attacked Englishmen; but this was not a difficult matter; in fact, having had an attack of the fever himself on first visiting Africa, he could safely say it was not so bad as the ordinary English cold. They had heard that scientific expeditions had been sent to the country, and of course every one knew what that meant, just as they knew what a Russian expedition meant; but he thought it would be much better to send out a mercantile expedition, though if this were not done in the course of a few months it would be too late. At the present time, large tracts of this magnificent country could easily be acquired, following the highlands of Usambara, Pare, and Ugweno, which are perfectly healthy, from the coast up to Kilima-njaro, and there was no reason why England should not organise expeditions to go and acquire these lands, more especially as the natives were begging them to come, and had already expressed a wish to be governed by the Queen of England.

Dr. Mann thought Mr. Johnston had most ably fulfilled the promise which he made two years ago, namely, that upon his return he would give a description of the country he was then going to visit. The subject was a most interesting one to him, as he had had some experience of African climate, having resided in Natal for about nine years, and the observations which he had made in reference to that had a direct bearing upon Mr. Johnston's experience. It was certainly a very surprising thing that in equatorial Africa there was such a climate as they had just had described, but of course the secret was the elevation. The highest temperature he had himself observed, during his residence in latitude 29½ south, was 97°, and Mr. Johnston, who had resided for nearly a year almost under the equator, found the highest temperature 91°.

Mr. Johnston said this was in the hottest part, and at an elevation of about 1,000 feet.

Dr. Mann remarked that 91° was low even for an Indian climate. In the hilly regions, no doubt, they would find districts where Europeans might look forward to a future of happy and wholesome work. In Natal Englishmen could work all through the summer without harm, and no doubt much the same might be done at Kilima-njaro. He was extremely surprised to hear the account which Mr. Johnston gave as to the small number of reptiles, such as dangerous snakes, to be found in this country, and should, at least, have expected to hear that snakes were as abundant as in Natal. He did not know whether the account which had been given applied mainly to the higher regions of the mountains, but in Natal there were several descriptions of venomous snakes, one being the imamba, which had the reputation of pursuing horsemen, though no doubt it merely did so when a horseman was crossing the line which led to its nest.

Archdeacon Farler said this snake was met with in Usambara, and he had known it pursue and seize a goat.

Dr. MANN said he knew of a horseman being pursued by one of these snakes, and having been so thoroughly impressed with the idea that he was pursued, that, after riding hard some miles, he provided himself with a high pair of boots in order to protect himself against being bitten. In Natal they were also troubled with a minute tick which buried itself in the leg, and he should be glad to know whether this insect had been met with in the district lately explored.

Mr. JOHNSTON replied that he had met with this insect, but not in Kilima-njaro.

Dr. MANN said he should also like to know whether in Kilima-njaro they were much troubled with what was known as the hot wind, which was occasionally a cause of trouble and annoyance in Natal. This wind, which generally commenced to blow in the middle of the night, and caused the leaves on the trees to wither, ceased in middle of the day, and about two in the afternoon the clouds would rise, to be followed by a thunderstorm, and in the evening the temperature would fall 30°, but in the middle of the night the hot wind would commence to blow again. This would generally occur for three nights in succession; it was not an injurious wind to health, as it lasted so short a time, though it was most disagreeable while it lasted. He should be glad to hear whether it was found in districts further north. In conclusion, he begged to thank Mr. Johnston for his extremely interesting and valuable paper.

Mr. LASCELLES SCOTT said, of the various interesting remarks which they had listened to, the one which most appealed to his commercial sense, as a chemist, was that relating to the fertile nature of the soil, as adapted for the growth of a variety of products which were constantly wanted in Europe, and more especially to the deposits, in this district, of large quantities of nitrate of soda. Some years ago, a small sample of nitrate of soda was handed to him, which he had every reason to believe came from this district, and upon analysis he found it to be of very fine quality and purity, comparing most favourably with any obtained from South America or Peru. He thought the export of this article alone would go a long way towards paying the expense of any expedition to the country, and that the district was admirably adapted for the growth, not only of the food staples, but plants valuable in the healing art. He should be glad if Mr. Johnston could give them any further information upon this point. Drugs, and valuable chemical products, which occupied but a small bulk, were the great things to be looked after in a country where the question of transit was a serious difficulty, and, therefore, he thought they should rather devote their attention to these things than to articles occupying a large bulk, and upon which the profits would not for many years be so great. With regard to a remark which had been made about scientific expeditions, it should not be forgotten that experts sometimes did more to open up a country, and to render its products valuable, than expeditions composed of men who did not understand the value of the things which they came across.

Archdeacon FARLER wished to say that his remarks did not apply to the kind of expedition referred to by Mr. Scott.

Mr. LIGGINS said that, with regard to reptile life, he thought that as a place became inhabited, snakes and the like very soon became exterminated, and, therefore, no danger on that score need be feared. In the West Indies they were much troubled by the sand-fly and the chigger, the latter insect getting beneath the skin of the feet, and, if not removed, breeding there, but a sure protection against these insects was the use of proper socks and boots. With regard to climate, he did not believe there was a bad climate in the world unless it was made by man. In his younger days Sierra Leone was called the Englishman's grave, but now, through the removal of bushes which formerly held the fever, there was no more healthy place; and in Antigua there had not been a case of yellow fever for the last twenty-eight years. With regard to the prospects of this new district in a commercial point of view, as reference had been made to the deposits of nitrate, he might say that, some years ago, having used nitrate of soda as a manure in the West Indies, he found that, as applied to sugar-cane, it was a terrible failure. Owing to the depressed state of agriculture at the present time in England, market gardeners could not afford to take away the refuse from stables, and, therefore, it was very unlikely that they would be able to purchase this nitrate, if exported, for the purpose of manuring the ground. The principal difficulty which had to be encountered in opening up any new country for the purpose of trade, was that of getting any Government in England to take the slightest interest in commercial enterprise. Some years ago the trade between London and the western ports was considerable, but now all went to America, simply because means had not been taken to foster it. It would be most disheartening to see such a fine country as Mr. Johnston had described remaining undeveloped, simply because the English Government would not give any aid or assistance.

The CHAIRMAN, in proposing a vote of thanks to Mr. Johnston, said he was very glad to hear the remarks of Mr. Liggins, because it was by criticism that the real value of a paper such as that they had listened to was tested. Every one knew that English interests had been grossly neglected in foreign parts by the various departments of the Government; but still they had not yet reached the depths of misery and destruction which it was competent for a Government department

to produce. One reason was that, fortunately, they were not so much dependent upon Government action as they were in some respects with regard to the West Indian Islands. This empire had not been built up by the Government, but by the independent action of its citizens. It was more than a century ago that the Society of Arts was founded for the purpose of giving organisation to the energy of the mercantile classes, and the intelligence of the community generally; and the object of the paper which Mr. Johnston had brought before them was for the purpose of obtaining that co-operation from the community, and influencing, in the first place, the mercantile class, and in the second place, if necessary, the department of Government which might be called upon to have some relation or connection with it. To some it might appear that the paper was the dream of an enthusiast, and of a very unpractical nature, but if Mr. Liggins would apply the experience, not of colonies 200 years old, but of colonies which had grown up lately, he would find that the district described by Mr. Johnston was exactly the kind of country described about 30 years ago, and which had since been worked upon and constituted as a colony. They had not to consider the present amount of produce which could be brought into the market, but whether, according to the old phrase, the country had capabilities which promised, under judicious management, to bring forth something. Although Mr. Liggins thought nitrate of soda, as a manure, had been a failure, it was well known that at the present moment that commodity was a great article of trade on the west coast of South America, and furnished cargoes for English ships. If the deposits in the neighbourhood of Kilima-njaro were of sufficient value, they might be the means of giving Mr. Johnston the railway which he said was necessary to develop the district. It was not their business here, however, to determine absolutely whether an individual article was sure to be a matter of profit, but merely to determine whether it was a thing worth inquiring into; and they must not set it aside hastily, even if they thought it was not likely to pay at the present moment. Many years ago he took the liberty of calling the attention of the Foreign and Colonial Section to the part of the country which had been described that evening as being one marked out by its climate as most suitable for Englishmen. With regard to what had been said about fever, it was well known that when persons went into a new country, and stirred up the ground, malaria was produced. In the history of the West Indian Islands there were cases of islands now bearing large populations which were devastated by fever on their first colonisation. In fact some islands could hardly be planted. That was dependent also upon the direction of the wind in which the malaria was carried. In one instance a French colony starting from one side lost the bulk of its colonists, whilst the English colonists starting to clear from the other side got on perfectly well, which was merely owing to the fact that they let in a healthy wind which drove away the malaria. This island was a very healthy place after it had been pierced through in that way. It often happened in tropical countries that fevers were driven away in this manner, so that it was not absolutely necessary that a person should be subjected to malaria fever in the opening up of this new district.

The resolution having been passed unanimously,

Mr. JOHNSTON, in reply, said that with regard to the production of cereals, it was generally imagined that the produce must be shipped to England, but that was an utterly false idea; the produce could be sold upon the coast, and a very good price would be obtained for it, much more so than if sold in the interior. As to nitrate of soda, that was found upon the plains south of Kilima-njaro, and to the north-west, but further information on this subject would be found in Mr. Thomson's book on Masai land. At Kilima-njaro the nitrate of soda was used by the natives mixed with snuff, and that was the first way in which he came across the article. With regard to drugs, he thought there was an admirable opening in this district, as there were many indigenous trees from which drugs could be obtained, though upon this subject he could not speak with certainty not having brought his notes with him. However he could say that the natives obtained many valuable drugs from the trees in the district. As to snakes, he might say that he had looked for them almost in vain, for with all his endeavours he only found four, of which one was venomous. He had not met with the imamba which Dr. Mann referred to, nor had he ever noticed or heard of the hot wind. Occasional violent wind storms occurred in the rainy season, but nothing so bad as was found on the Congo. The climate of the country could only be described as that of a Devonshire summer.

INDIAN SECTION.

Friday, April 17, 1885: W. G. PEDDER, Member of Council, in the chair.

The CHAIRMAN, after expressing regret for the unavoidable absence of Lord Napier of Magdala, said that the reader of the paper appeared as the representative of a race, few in number, but remarkable, not only for intellectual eminence and commercial enterprise—of which the paper would afford ample proof—but from a historical and ethnological point of view. With the exception of the Jews, he believed that the Parsis were the only example of a people who, driven from their fatherland, have dwelt for more than 1,000 years in a foreign country, intermingled with an alien and infinitely more numerous population, yet have retained, almost unaffected by that close and constant intercourse, the purity of their blood, their national manners, customs, and

dress, their religion—the ancient and famous religion of Zoroaster, professed by the Magi who visited Bethlehem 1,900 years ago, to a great extent even their language, and who, after the depression, and often persecution, of many countries, have emerged to a position of eminence, and, considering their scanty numbers, of extraordinary importance in their adopted country. Personally, he had the greater pleasure in being present on that occasion, because the reader of the paper was the son of a gentleman whose friendship he had enjoyed for many years; who is not only eminent among his own countrymen, but is one of the most trusted and most distinguished among the servants of the Queen in Western India, and who has lately published a book on the history of his race, which will well repay the perusal of every Englishman interested in the East.

The paper read was—

THE PARSIS AND THE TRADE OF WESTERN INDIA.

By Jehangeer Dosabhoy Framjee.

The subject which I have to bring under your notice this evening is the position of the Parsis in Bombay, and their share in the trade of Western India. The subject is doubly attractive to me, first as a Parsi, and secondly, as a member of the uncovenanted Civil Service, holding an appointment in the Customs and Opium Department in the great port of Bombay; and I venture to believe that the facts, however imperfectly I may treat them, will be found interesting, both as recalling the chief passages in the life of the Parsi community, and also as relating to one of the most important sections of the commercial activity of the Indian Empire. There is, as will be seen, an intimate connection between the two things. The rise of the Parsi community to affluence and prosperity was contemporaneous with the commercial development of India, which began with the arrival of European traders on her shores, and which, progressing by leaps and bounds as the English authority became consolidated in the country, now promises to attain dimensions far exceeding the most sanguine expectations under the sway of the Queen Empress and her successors. In that commercial development the Parsis can and do claim no small part, and while it is my purpose to show what their share in the credit and profit thus acquired has been, I shall also have to deplore the decline, or at least the stationary character, of their participation in it during the last few years, to assign some reasons for this, and to indicate how, in the future, we may hope to restore the more favourable state of things that existed at an earlier period.

The trade of Western India is now the trade of Bombay. At first—and, indeed, the story of Parsi commercial intercourse with Europeans goes back to an older period than the cession of Bombay to England—it was different; and Surat, Broach, and other places, were, for some time, the successful, and for a much longer period, the bitter rivals in trade of the present capital of Western India. But this is completely changed, and the trade, both sea-borne and coasting, has long centred in the port which ranks, after London, as the most populous city in the British Empire. The nature of that trade, for the last official year 1883-4, is fully explained in a volume of nearly 500 pages, which has lately been published by the Commissioner of Customs and Opium in the form of his "Annual Statement of the Trade and Navigation of the Presidency of Bombay." I can only attempt to briefly summarise here some of the principal results, and to give a few of the more important totals. The total value of the sea-borne trade in 1883-4 was 832,703,526 rupees, or a sum nominally exceeding eighty millions sterling. In this total, stores and treasure on account of Government are not included. The returns show an increase over the previous year of more than five per cent., the only branch of trade showing decrease being that with the few ports in India which are under French or Portuguese authority. Two-thirds of the import trade is with England, and one-fourth of the export trade proceeds to the same destination. China purchases from Bombay twice as much as she sells, and the return in cash from this quarter alone does not fall short of three millions sterling. France stands next to China as among Bombay's most profitable customers, and there is a steadily increasing trade with Belgium, Holland, and East Africa. The trade with foreign external ports represents more than three-fourths of the whole total, and the exports exceed the imports by something less than two millions sterling. I need not refer particularly to the other branches of trade with foreign Indian ports, British ports in other Presidencies, and British ports within the Presidency, which raise the amount to the total of eighty millions. In order to arrive at the real commercial importance of Bombay, we must add an extensive coasting trade and a valuable traffic by railway with the interior of India. Bombay is also the place through which passes the

whole of the official communication between England and the Government of India. Kurrachee threatens to rival Bombay, or to relieve the strain so far as North-West India is concerned; but up to the present time, Bombay derives all the importance and advantage from the monopoly of being the chief channel of communication between London and Calcutta and the other large towns of India. Although Calcutta, Rangoon, Madras, and Kurrachee are in their way places of great importance, and the centres of an extensive trade and industry, yet it is true that Bombay enjoys a commercial pre-eminence in the East of which it has not yet been deprived, and of which there are at present no signs that it ever will be deprived. Its convenient position with regard to England, and its profitable intercourse with China, afford the basis on which rests its great prosperity; and with these introductory remarks as to the extent and character of the trade of this Indian Liverpool, I will turn to the chief part of my paper, the position held by the Parsi community in this busy hive of human industry.

It will be appropriate to state here, as briefly as possible, who the Parsis were, and whence they came. The Parsis are the real descendants of the ancient Persians, who attained the pinnacle of human power under Cyrus, and whose long struggle under Xerxes and Darius with the Greeks forms one of the most entrancing passages in history. They derived their name from the Persian province of Pars or Fars, whence they may be supposed to have last come after the Mahomedan conquest compelled them to seek a new home in India. The Parsis first arrived at the port of Diu in the Gulf of Cambay, still, and for a long time a Portuguese possession, but after a brief sojourn there, they sailed for Gujarat, and by the permission of the Hindu Raja, established a new settlement at Sanjan. When our ancestors, rather than accept the Koran, abandoned their country and went into exile, they were completely destitute of all resources, and had to depend on the forbearance and assistance of those among whom they sought refuge. They remained at Sanjan for several centuries undisturbed and prosperous, until the arrival of the Mahomedan invaders from Afghanistan threatened to involve them in a common ruin with their Hindu protectors. The Mahomedan invasion disturbed the harmony of their existence, and after bravely sharing the perils of the Hindus of Sanjan, the Parsis suffered in common with the rest of the population. They were compelled to take refuge in the mountains, and it was only after some years that they emerged from their obscurity to found a fresh colony at Bansda. Their next move was to Navsari, in the year A.D. 1419, with which event their history as a commercial community may be said to have regularly begun. I have not ventured into any details as to the earlier history of the Parsis in Persia, or during their residence of many centuries in different places of the province of Gujarat. It is the less necessary for me to do so, as my father, Mr. Dosabhoy Framjee, of Bombay, has quite recently published in England an exhaustive account of the Parsis and their numerous vicissitudes since they lost their imperial greatness—if not their independence—on the field of Nahavand. The fact is indisputable that the establishment of Parsis at Navsari in the fifteenth century, on the eve of the arrival of members of the great trading nations of Europe, marked the commencement of their activity in commercial and industrial pursuits, from which they have no doubt derived their present importance. While Navsari long remained what may be termed their religious capital in India, from the circumstance of its containing their chief fire temple, with the sacred fire perpetually burning, Surat, Thana, and Bombay were all the scenes of their greatest commercial activity and success.

During their first residence in Gujarat, the Parsis devoted themselves to agriculture. The first industry to which they seem to have turned their hands was weaving, and the earliest evidence of their growing activity was afforded by their exporting to other parts of the province the grain and manufactured articles for which they had obtained a reputation. By the tenth century their articles had found a market in Cambay. But it was with their arrival in person at Surat and Navsari that they came more prominently forward. They soon succeeded in establishing friendly relations with the Dutch, Armenian, and Portuguese merchants who had been permitted to found factories at these places. These foreign merchants, ignorant alike of the language and customs of the place, found the Parsis of such great use that they freely employed them in the capacity of agents. By this means the Parsis both acquired an aptitude and experience in business, and also a good reputation for honesty and faithfulness to their employers, which stood them in good stead at the time,

and which, I am proud to say, has never subsequently abandoned them. At first the Parsis were only the servants of the foreign merchants, but even that condition showed a great advance from the simple state of agricultural proprietors and labourers in which they had so long existed in Gujarat. But after a time, they, or some of of them, gradually acquired a more independent position, as well as an increased share in the trade that was carried on. They became brokers and agents, and some of them even made ventures on their own account.

The Portuguese appear to have been the first to come into close contact with the Parsis, and to have availed themselves of their services at the beginning of the sixteenth century. But in the year 1660, the English established a factory at Surat, and finding the Parsis fully recognised as the most eligible intermediaries with the natives by the other Europeans, hastened likewise to avail themselves of their services. The jealousy of the Dutch and Portuguese naturally placed considerable difficulties in the path of the English merchants, and it is not improbable that, if they had failed to enlist in their behalf the sympathies of the Parsis, the English would have been compelled to abandon in despair all idea of promoting a trade with the natives at Surat. The local obstruction proved of so serious a character, that the chief of the English factory found it necessary to undertake a journey to the Court of the Emperor Aurungzeb, in order to complain of the exactions of his officers on the spot, and to demand protection in the future. The success of his mission was due to the efforts of the Parsi Rastam Manak, who accompanied the Englishman to Delhi. Rastam Manak was the chief broker of the English factory, and the decided success of his negotiations strengthened the good feeling and business relations between the Parsis and the people of this country. The services of Rastam Manak in this delicate negotiation proved the precursor of a long career of usefulness in the commercial affairs of the old East India Company. It was through the Parsi brokers that the English disposed of their goods to the people, and purchased the productions of the country in return.

While the connection with the Europeans was profitable to the Parsis, it also served to stimulate their energies and to encourage them to become merchants on their own account. At first these operations were tentative and on a small scale, but gradually acquiring confidence and capital, they extended them into several branches of trade, and even acquired the monopoly of some of them. Those who were not engaged in commercial pursuits exchanged agriculture for various handicrafts, and the best weavers, potters, and carpenters were admitted to be found in their ranks. The silk cloths known as bastas, alechas, and khinkhobs, manufactured by Parsis, gained a reputation all over India. Their skill as carpenters soon developed with the opportunity into proficiency as shipwights, and the construction of the earliest ships at Surat was accomplished mainly by their efforts. When the dockyard was built at Bombay in 1735, Parsis were not only the principal people employed in its construction, but also in the building of the ships which it turned out for more than a century after it had been completed. The family of the Wadias long enjoyed the foremost position among the shipwrights of India, and their skill was handed down for several generations, from the time of Lavji Wadia, who joined the Bombay Dockyard in the middle of the eighteenth century. It was their approved ability in the construction of ships which gained the admiration of English builders, and first induced the Admiralty to order men-of-war to be built in India. These vessels were remarkable for their strength and sea-going qualities. I will here give two quotations, which will bear out my statement as to the skill and superiority of the Wadias as shipwrights. The Superintendent of Marine reports to the Government of Bombay in the following words:—

"The masterly execution of these orders has nobly redeemed the pledge which that distinguished Admiral gave in England. The frigates of thirty-six guns each have been highly approved of, and the seventy-four rides in this harbour, a proud monument of Jamshedji's skill in naval architecture, and the admiration of all professional men."

In England likewise the opinion about the vessels built by Jamshedji was highly gratifying to him, and exceedingly creditable to his merit and ability. Vice-Admiral Sir Edward Pellew, Bart., wrote to the Superintendent of Marine at Bombay to beg him to tell Jamshedji that he ought to be proud of his frigates. He said:—

"The *Salsette* sails as well as any of our frigates, stands up better, and had any other ship but her been frozen up in the Baltic as she was for nine weeks, she would not have stood the buffeting of the ice one day,

whereas she came off unhurt. It was wonderful the shocks she stood during heavy gales."

At other places the Parsis followed different pursuits. While Surat was known for its khinkhobs and other woven articles, and Bombay for the general commercial activity of this people, Broach, was famous for the cultivation of cotton and for its manufacture. Another subject to which they turned their attention was the rôle of Government contractors. They accepted contracts not merely for the supply of provisions, or the erection of Government buildings, but also for the recovery of arrears of land revenue. When, as time went on, the operations of the English Company became less exclusively commercial and peaceful, the Parsis took their share in the numerous enterprises which resulted in the triumph of the English over all their rivals and in the extension of their power. The Parsis were most conspicuous in supplying all the requirements of a commissariat department, not merely providing transport and boats, but provisions, clothing, and water. The Parsi contractor invariably accompanied the army in the field. It is hardly necessary to say that as they performed this rôle under such difficulties, they were equally energetic in obtaining the much easier and less dangerous provisioning of the many ships arriving at Bombay.

At a very early period of English intercourse with India, the Parsis had acquired a name as honest brokers, which ensured their services being in continual request. They soon revealed special qualities and characteristics. Among these, after their honesty, the most conspicuous was their enterprise in entering upon new undertakings and in extending their operations to distant countries. They stationed agents in all the principal places with which they traded, and their names are to be met with many generations ago at Madras. The close intercourse between Bombay and Fort St. George explains the early connection of the Parsis with the Coromandel coast, and we learn that this trade produced a profit of one hundred per cent. Similar results were obtained from intercourse with Java and the Mauritius, but the principal source of Parsi prosperity was the trade with China, which assumed much larger dimensions than any other branch of the external commerce of Bombay. In fact the China trade brought them immense profit, and it was only after their connection with that country that they began to be considered exceedingly wealthy. There are instances recorded of Parsis having returned from China with their capital doubled in a single voyage. In many account-books still existing in the families of those identified with the older Parsi firms, it is shown that a bale of cotton produced a profit in China of 50 taels, or about 200 rupees. Equally large profits were made on other articles. The precise date of the commencement of Parsi intercourse with China is a little uncertain. It seems, however, to have begun about the year 1756. It is stated that the Hong merchants, to whom the external trade of Canton was entrusted, were very frank, simple, and honest traders, and that the Parsis succeeded in establishing the most cordial relations with them. The cargoes taken out consisted principally of opium or cotton, and the ships returned with a new freight of which no inconsiderable part was cash. The Chinese used, at the close of the season, to compel the Parsis to leave Macao and Canton, and it was believed to be due to an idea among the Chinese that the Parsis ought, as soon as they had finished their business, to hasten back to their own wives and families. The inconvenience arising from these frequent voyages to and fro induced the Parsis to establish a depôt at Penang, where the merchants from China found it most convenient to meet their agents from Bombay. In order to keep pace with the requirements of a rapidly increasing commerce, the Parsis built ships of their own, and thus laid the foundation of increased prosperity. For a long time they possessed, practically speaking, the monopoly of this portion of the foreign trade of India, and, by a natural process, they succeeded in opening up commercial relations with the countries lying between India and China. They also turned their energies in the direction of Arabia and Madagascar. Their success in their own concerns induced many to think of employing them for their own advantage, and the ruler of Mysore absolutely entrusted the improvement of his state in commercial matters to a member of our community.

At one time the Parsis seem to have dealt very largely in importing articles of consumption among Englishmen. As a natural consequence, they engaged in money transactions, and at a period when banks were unknown in India, it was they who conducted in their shops or offices all the financial transactions both for Government and private persons. At one time they used to sit in the open air on

benches in the Parsi bazaar street, where they transacted in this fashion all the business of banking. They were money changers, dealing freely in the various coins of the East, lending money to private persons and public contractors. They undertook what was then a matter of the greatest difficulty—the remittance of sums of money from one place to another. Among other of their self-imposed duties they undertook to deliver letters wherever they had agents, and it was not until the year 1852 that Government took this work out of their hands.

The direct trade of the Parsis with England is not extensive; but more than one Parsi firm exists in the City of London, so that the example set by the Camas in 1855 cannot be said to be barren of result. The Camas, I may remark, sustained the reputation, in England, of the Parsis for commercial integrity, and also for benevolence, by their liberal donations to various charitable institutions in London. Until the application of steam to ocean navigation, the Parsis possessed an important share in the shipping trade of Western India. In 1793, the Parsis had twenty-one ships, of which the largest exceeded 1,000 tons, and down to the year 1845, these steadily increased in number. During the first Chinese war, 1839—42, the Government chartered fifteen vessels of a Parsi merchant established in Calcutta; but the introduction of steamers produced a gradual change. Whether they disregarded the importance of the change this would make in the conditions of trade with China, or whether they did not possess a sufficently large capital to enable them to cope with the new conditions, the fact is certain that they gradually lost the monopoly they enjoyed; and the treaty opening the Chinese ports to foreign trade, far from increasing their share in its perquisites, proved the commencement of that steady decline which has continued ever since, until only three or four Parsi firms are left to represent their old connection with China.

Thwarted in this direction, the Parsis turned their natural energy into other channels. As far back as 1854 they had opened several spinning and weaving mills, the first of which, known as the Bombay Spinning Company, was established by Mr. Cowasjee Nanabhai Davar. This concern was so successful, and paid such high dividends, that it immediately found several imitators. The Oriental Spinning and Weaving Company, founded in 1858 by the late Mr. Manakji Nasarvanji Petit, for the manufacture of yarn and cloths, was the most important, as it has proved to be the most successful. Whatever dimensions the cotton trade of Bombay may assume—and it is doubtful if it ever again can attain those it reached during the American Civil War—there is no question that it supplies, as far as we are concerned, but inadequately the loss of the old pre-eminence of the Parsis in the China trade. The share mania, followed by a disastrous panic twenty years ago, inflicted a rude blow on the commercial prosperity of the Parsi community; but there is every reason to say that without that catastrophe the China trade would have slipped out of our hands. The Jew merchants, whose rivalry has proved so serious and successful, were at that time really better informed than the Parsis, and saw more clearly how the best was to be made of new opportunities. They also had the command of more capital, and, under the circumstances of introducing steam vessels and taking full advantage of the new Chinese ports and provinces opened to trade, this was the chief essential to success. The Jews transacted their business in a much larger way than Parsis of the old school had ventured to carry on, and thus they obtained large advantages in the important matters of freightage and insurance, which alone represented no inconsiderable profit on the whole outlay. The necessary consequences ensued. The Parsis were ousted from the trade in which, so long as it was carried on with Canton alone, and in sailing ships, they had been supreme, and at the present moment there are very few Parsis engaged in that branch of commerce which made the fortunes of so many of our leading families. I cannot refrain from mentioning here how large a portion of those fortunes was devoted to charitable objects. The Parsis owe their reputation not so much to the manner in which they accumulated their wealth, but to the way in which they have dispensed the store with which Providence blessed them. Foremost among those benefactors were the late Sir Jamshedji Jijibhai and the late Sir Kavasji Jehangir, who both contributed in the most lavish manner to objects of public utility and benevolence. The Parsis freely give out of their capital to any cause that enlists their sympathies, and even at the present day they are not less remarkable than before for their generosity and benevolence. I may be pardoned for mentioning out of several only three instances of recent occurrence. One is of Mr. Pestanji Hormasji Cama, who gave the sum of 160,000 rupees

for an hospital for the exclusive treatment of women by properly qualified European lady doctors. The second is that of Mr. Dinsha Manakji Petit, who gave a large sum of money for building an hospital for the treatment and care of animals. The third instance is that of of Mr. Sorabji Shapurji Bengali, who gave Rs. 65,000 for the building of a girls' school in one of the most populous parts of the town of Bombay. These facts show that the Parsis still endeavour to carry out that injunction of their religion which bids them promote all charitable works.

There are, moreover, no signs that the Parsis will yet regain the former position as dealers in merchandise. So far as their part in the commerce of Bombay or Western India is concerned, Parsis are now solely interested in the cotton spinning and weaving industries. Thus by this means they still possess the prominent position which they formerly enjoyed in the trade with China under the Jamshedji Jijibhais, the Camas, the Alblesses, the Kavasji Palanjis, the Tatás, and many more. No doubt the loss of their share in this branch of trade has been felt very acutely by the Parsis, more especially when it is recollected how great has been the increase of the commercial activity of India during the last forty years. Dr. Hunter states, in his "Gazetteer," that "at the beginning of the last century, before the English became the ruling power in India, the country did not possess one million pounds worth a year of staples for exportation," and that, "during the first three quarters of a century of our rule, the exports slowly rose to about ten millions in 1834." The whole trade of India, import and export, averaged in the five years, 1834 to 1839, not more than sixteen millions, and now, as I have previously stated, the trade of Bombay alone exceeds 80 millions, while that of the whole of India is nearly 150 millions sterling. In the earlier development of this trade, the activity and commercial instinct of the Parsis played no small part, and no doubt their freedom from caste and other prejudices facilitated their operations in foreign countries, and among strange peoples. Their virtues and capabilities were summed up by an old writer in the following sentence:—"Their pluck, spirit of submission acquired by bitter experience, and habits of perseverance, led them to occupy no mean position by the side of European traders." The strongest testimony to the probity and efficiency of the Parsis as merchants was given long ago by Sir Charles Forbes, head of the great Bombay firm of that name, when exhorting his partners to follow the advice, during his absence, of his Parsi assistant, Mr. Hormasji Bamanji Wadia:—

"I know from experience the value of his clear judgment and excellent opinions. I profited by them; nor are they to be rejected upon the first impression, but let them be well weighed, and I venture to say that others will do as I have done—lay aside their own and act upon his. More especially his superior knowledge of bazaar credit ought to be attended to, founded as it is upon long experience and a more intimate knowledge of the native character than Europeans can possibly acquire."

What Sir Charles Forbes wrote of Hormasji Bamanji Wadia might have been written of many another Parsi, for he was only a type of his class. I cannot refrain from quoting here one instance related by Mr. Sorabji Shapurji Bengali, of Bombay, in an account he wrote of his travels in this country. He says that whilst travelling in Scotland, he met, on board the steamer between Oban and the Island of Mull, a passenger, who told him that, having heard of an Indian firm in London which wanted some saw-mill machinery, he went to see one of the partners, and, after quoting certain prices, offered him a discount, or commission, if he would accept his tender. The Parsi replied, "We personally do not receive such discount, but make any allowance you like and deduct it from the invoice, as our clients are entitled to all allowances." Parsi merchants were all animated by the same spirit of integrity as that which inspired this Parsi gentleman, whose name I may mention, Mr. Dadabhai Naorozji, as I believe he had the honour of reading a paper, some years ago, before this Society.

Mr. Sorabji Shapurji Bengali, whom I have just named, detected so long ago as 1859 symptoms of approaching decline in the commercial activity and enterprise of his community. He stated that the Parsis were slowly receding from their foremost position in trade among the natives, and that at the same time they were losing some of their self-reliance and boldness. The growing spirit among them was to look out for certainties, and venture nothing. Many who would formerly have aspired to trade on their own account were nowadays well satisfied by accepting subordinate positions in European mercantile houses, which of course would present little or no prospect of permanent

reward or position. This opinion of a Parsi on Parsis may be a little too hard, and the expression of one who is *laudator temporis acti;* but there is much truth in it, so far as the present trade of the Parsis in the external trade of Bombay, apart from the cotton industry, is concerned, and particularly as contrasted with what it was at an earlier period. The trade of Western India is developing with rapid strides ; and although the Parsis, who were among its pioneers, have lost their vantage ground, they should, as they retain the salient characteristics of their forefathers, be able, if they would but energetically devote themselves to the task, to obtain some share in the ever expanding commerce of which Bombay is the central point.

Although the Parsis are no longer the merchant princes which they once were, they retain their prominent position in the Bombay community by virtue of the progress which they have made in education, and in all the requirements of civilised society. The liberal professions and the Government services have provided fresh avenues of distinction of which the Parsis have taken full advantage. The cause of their success in these new careers is to be found in the eagerness with which they have embraced all means of improving their minds, and in the thoroughness with which education has been spread among all branches of the community. Among Parsi boys, not five per cent. fail to attend school ; and in Bombay this is equally true of girls. In the Mofussil, female education is not quite so far advanced, but still, everywhere the education of Parsi girls is the rule and not the exception. The earlier Parsis who helped the English merchants, and who played the part of brokers between them and the natives, were not educated men, although in shrewdness and in good sense they could have held their own. Education among the Parsis certainly does not go back further than the commencement of the present century. The mass of the Parsis had given up the use of their own language, the Persian, and had adopted, at an early period of their residence in India, the Gujarati vernacular. A few of the Dasturs, or head priests, studied Persian, but if the majority of the Parsis at Surat and Bombay, during the first century of their intercourse with Europeans, added to their adopted tongue a smattering of English, that was the extreme limit of their attainments. The few schools which existed in Bombay at the beginning of the century were of a very elementary kind, and a large proportion, if not an absolute majority, of the pupils were Parsis. The great impetus to education in Bombay, in 1820, was given by the Honourable Mountstuart Elphinstone, that famous English administrator and highly gifted man, when he founded the Bombay Native Education Society. As the name of Elphinstone was thus associated with the dawn of education in Bombay, so was it to be permanently identified with its course and development, by the founding of the great institution which bears his name. While the benefits of this institution were not withheld from any race or religion, none hastened to avail themselves with the same avidity of its advantages as did the Parsis. Although the Parsis are very few in number, being no more than 100,000, they have generally been able to claim a very large proportion of the students at the Elphinstone College as their kinsmen. This fact is not less gratifying than remarkable, and fully explains the subsequent success of the Parsis whenever the test of an examination decided the rewards of merit. The Parsis have also educational establishments of their own, and restricted to their own people. Of these, the most important is the Sir Jamshedji Jijibhai Parsi Benevolent Institution, founded in 1842, by the most distinguished of all the Parsis. Eleven schools for boys, and the same number for girls, in Bombay, and the mofussil, are maintained out of this charity. The four boys' schools in Bombay have a roll of 1,100 pupils, and the girls' schools number 900 students. In the 15 schools in the mofussil there are more than 1,000 scholars, and the regularity of the scholars' attendance is not less remarkable than their numbers, although absentees are, necessarily, more numerous among the girls than the boys. The results attained are equally creditable to the Parsis as scholars, and to their system of training, especially as this education is free. It should be observed that Mr. Dosabhai Nasarvanji Wadia, the principal of the Sir Jamshedji Jijibhai Benevolent Institution is a Parsi, a distinguished graduate of the Bombay University, whose administration and management of the schools under his charge have met with unqualified praise from different educational inspectors who have examined the schools on behalf of the Government. Another gratifying instance of Parsi prominence in educational matters is worthy of mention. Mr. Jamshedji Ardeshir Dalal, a distinguished graduate of the Bombay University, has recently been appointed to the

Principalship of the Gujarat College. There are also several private high schools conducted by Parsis, where with a few exceptions the students are all Parsis, and of these schools the two principal have a muster roll of 1,200 pupils. On passing the matriculation examination from the above-mentioned schools, a great number of them join the Arts, Medical, and Engineering Colleges, and obtain degrees at the University. Several instances may be mentioned of Parsis who have gained many honours as barristers and candidates for the Civil Service. For instance, it was a Parsi gentleman, Mr. Mancherji Pestanji Kharegat, who occupied the first place in the final competitive examination for the Indian Civil Service, held in London in 1884. Another instance, in a different branch, may be cited of Mr. Rastamji Dhanjibhai Sethna, who, in open competition with all the students of the four Inns-of-Court in London, took several prizes, amounting in value to 160 guineas. These results show how fortunately their efforts have been crowned and rewarded. Parsis are now prominent in every walk of life in the Bombay Presidency for which talent and knowledge are the necessary passports. They are to be found not merely as barristers and teachers, but as members of the Civil Service, both covenanted and uncovenanted. In the latter capacity they serve as magistrates, revenue officers, and judges. Parsis are also well known, and I could mention many names in support of my statement, as physicians, engineers, and journalists, in all of which capacities they have distinguished themselves. The higher forms of literature remain to be attempted, but we may hope that writers of works worthy to live will appear in due time, although it is not impossible that their most successful attempts in a higher style will yet be made in the English language, which is, after all, not more foreign to them than the one they have adopted. These new pursuits have provided the Parsi community with an industrious and not impecunious means of livelihood. Among no other race in India is there a higher level of general prosperity. The poor are very few, and the beggar hardly exists. The loss of exceedingly great fortunes is hardly appreciated when there is so good an average of general welfare and contentment. We have to deplore the loss of those kings of commerce who gave the Parsi name a world-wide reputation, but, on the other hand, we possess a contented community, living in a state free from the cares of life which may well create a feeling of satisfaction among its members, and one of envy in those who regard so agreeable a condition of things.

The energy, I am justified in saying, which characterised the early Parsi merchants, has not departed from their descendants, although it has found vent in new directions. The Parsis have lost that share in the trade of Bombay which might almost be considered as their birthright, but they have succeeded in obtaining no inconsiderable compensation in other directions. They may almost claim additional credit for having successfully coped with new conditions, and for having asserted their ability in spheres more intellectual than the disposal of opium to the people of the far East. Other races, when deprived of one opportunity which they knew how to take advantage of, would have succumbed to the fresh difficulties that necessarily presented themselves, but not so the Parsis. Even if they should never recover the position which they have lost as merchants, they have still a great career before them as official administrators under the Government, and as the enlighteners of coming generations among the peoples of India. In conclusion, I must add, that it would be an ungrateful omission if I neglected to state that the advantages which the Parsis, in common with the other races of India, now hold, and have long held, are exclusively due to the generous and beneficent policy of the English nation. It is unusual, I might almost say unprecedented, for the conquerors to give the subject so large and honourable a share in the conduct of public questions, but such is the glorious and remarkable character of the English administration of India. There are those who, because they have got much, complain because they have not got more. The Parsis are not of this kind. Satisfied with the conditions under which they exist, they are well content to believe that they hold their own future in their hands, and that time, the great healer of all wrongs, will bring in due course the realisation of all their just aspirations.

DISCUSSION.

Mr. Mowatt said Mr. Framjee had given a brief history of the commerce of Bombay, and of the share which the Parsi community had taken in it, and, if anything, he had under-estimated what they were doing at the present time. Although they had found it necessary from time to time to shift their ground, their genius for money-making was as keen

as ever, and whenever they did make a change—as from the foreign trade (which is now subjected to severe competition) to that of manufacturing—they generally selected what offered the most profitable investment. India was now becoming a great manufacturing country, and their industry was bound to grow. With cheap labour and raw material, it could not well be otherwise. Mr. Dinshaw Manakji Petit was quite as much a prince of manufacturers as the first Sir Jamshedji Jijibhai was a prince of merchants. Wherever you found the Parsi he was able to hold his own, and what enabled him to do so was the manner in which he looked ahead. He was not aware that the trade of Bombay had yet reached 80 millions sterling per annum, and he hoped Mr. Framjee would verify his figures before the paper was published. He had no doubt, however, it would soon do so, because Bombay, from its geographical position, and connection with the leading lines of railway in Western India, was likely to carry off the lion's share in the great grain trade which India was rapidly developing.

Mr. Foggo said he had known many distinguished benevolent Parsis in Bombay, and although it was true, as Mr. Framjee had remarked, that owing to circumstances which might be considered disastrous, connected with the share and cotton mania of 1863 to 1866, great mercantile calamities fell on the Parsi community there, still those events might have been one cause of directing their energies into other channels. There was no doubt that the Parsi community were completely carried away by the speculative mania at that time, and many honoured names were depreciated in reputation, and from the losses then sustained many of them had not recovered. He was not old enough to remember, in Bombay, the first SirJamshedji Jijibhai, the first remarkable person of his family, who was created a baronet chiefly on account of his great beneficence and other noble qualities, the present Sir Jamshedji being the third baronet. His portrait had been presented by a member of the family of the Earl of Clare, who was at one time Governor of Bombay, to the Oriental Club in Hanover-square, where it might be seen by those interested. His name as a merchant was well maintained by one of his sons, Rastamji Jamshedji, who died, he feared, of a broken heart, at the time of the cotton mania. Another very remarkable Parsi was Sir Cavasgee Jehangeer Readymoney, who was knighted, and who, amongst other acts of beneficence, erected a drinking fountain in Regent's-park. Mr. Pestanji Cama, the munificent father of a gentleman whom he saw in the room, had already been mentioned as having founded a hospital for women. With regard to ship-building, too, he could testify that what had been said respecting the skill of the Parsis did not go at all beyond the facts.

Mr. Bhownaggree, as a member of the Parsi community, said he might bear out the statements which had been made in the paper, that the part taken by the Parsis at the commencement of the British rule in India was not at all exaggerated. He had had occasion lately to pass in review a recent work on the brilliant deeds done by Parsis, and in the course of studies in that connection had to pass over a few details which he found were very well put in the paper. Probably want of time had prevented Mr. Framjee from giving a brief history of those great men, such as Sir Jamshedji Jijibhai, and Sir Kavasji Jehangir, who made great reputations as citizens in Bombay simply from being Parsi traders. He thought if Mr. Framjee would give another paper in which he might narrate the difficulties with which these great men had to contend in making their way in the world, it would be very interesting to a community like the English, who, on more than one occasion, had shown the greatest sympathy and good will towards the Parsis. He had no doubt that the figures given by Mr. Framjee were founded on official returns, to which he had access.

Mr. Brandreth said during his long service in India he had always taken the greatest interest in this race; wherever he met them he found them the most useful and trustworthy men he came across. It was very remarkable that a race numbering only 100,000 should have made such a prominent name amongst the 250,000,000 of India, and the spectacle of a people who could do so much with such very small opportunities, must commend itself to the sympathy of all Englishmen. One point which perhaps had not been sufficiently brought out was the way in which the Parsis always took the side of the English. In every time of struggle and necessity they were always on our side; they were almost more English than Indian, and he trusted that before long they would be admitted to our volunteer regiments.

Mr. Martin Wood remarked that it was extremely pleasant, in these times of political excitement, to have a subject brought forward which did not introduce any controversial topic, and this subject particularly was especially interesting to those who had resided in India, calling up as it did many interesting recollections. He had no doubt that, besides the Chairman, many present could count amongst their best friends members of the Parsi community, which had its representatives in all classes of society, from the original agricultural population in Gujarat to the great traders in Bombay, where they occupied a prominent position in society. There were many incidents in the early history of the Parsis that might be enlarged upon, especially the mode in which they encountered those early difficulties which had been alluded to. It was quite true that the commerce of Western India centred in Bombay partly from natural advantages, but more through reasons of an administrative character, and he was sometimes inclined to think that, as practical engineer-

ing work went forward, the country at large, rather than the existing towns, ought to be considered. Thus that direct commercial intercourse with Northern Gujarat might to be restored to the mouth of the Nerbudda, and other places where harbours could readily be formed. This, again, would give an opportunity for the display of that versatility which the Parsis had manifested in all new enterprises. With regard to the remarks quoted from Sorabji Shapurji Bengali, showing the rather gloomy estimate he formed of the future of the Parsis, the speaker thought, perhaps, Mr. Shapurji himself would now qualify that opinion to a certain extent; not that they were likely to take the same relative position that they did in the best times of the China trade, but he was sure there was amongst them sufficient energy and recuperative force to overcome the discouragement which had been alluded to. The majority of their active and intellectual members had taken to the scientific and other professions, and in that way found a new field of activity; not so suitable for making large fortunes, but one which added to the dignity and honour of the people. He wished that some of the lower and middle classes of the Parsis would show a readiness to strike out practical lines of action, and take up some of the pioneer rough work of mechanics and manufactures, by which means they might give a very much needed impetus to the whole industrial system of Western India; and this would be quite in accordance with their former characteristics. The great Sir Jamshedji himself began in that way, with industrial operations, which gradually changed into large trading pursuits. Reference had been made to the Magi and the Greek historians, but it should always be borne in mind that the story of the ancient Persian monarchies was told first, and for a long period, by the Greek historians. In fact, it was the lion painting the man. In late years, however, owing partly to the researches of German historians, a fresh light had been thrown on the relative position of the ancient Persians and Zoroastrian people. For it must always be remembered that the great Persian monarchies that held sway over Greece for centuries were Zoroastrians. They were not such a literary people as the Greeks, who constantly had, for many generations, the ear of the world. It was generally said that the Parsis in India owed many of their advantages to their freedom from caste, but that was rather an imperfect explanation. Not only that, but they had shown a great adaptability to the country to which they came. He did not attach much importance to the circumstance that they submitted to the conditions of the Hindoos of Gujarat, who were pre-eminently vegetarians, and required them to take a solemn oath never to do any harm to the sacred cow. They adapted themselves to all the circumstances of India, and in all its different provinces to which they travelled. At present, he feared, they were too much localised, and not quite so ready as they were formerly to go to other parts of India. They showed considerable enterprise in coming to this country, but he wished they would show more readiness to move to other towns and parts of India. Mr. Framjee had paid a just tribute to the equity of British rule in India, to which Parsis owed so much; but it should not be forgotten that the Hindoos showed a large toleration in receiving these fugitives from Persia, and treating them so liberally.

Mr. Mull said he had the pleasure of knowing intimately the father of the gentleman who had read the paper for more than thirty years, and he was, therefore, much interested in listening to it. For that period he had had a considerable number of Parsis in his employ, and without their assistance, especially in the early days of printing in India, it would have been difficult for him to have conducted journalism effectively. He had Portuguese, Hindoos, Mohammedans also in his employ, but the Parsis surpassed these races in every way; for, though the latter were willing to do what was required, they were wanting in the strenuous qualities necessary in journalistic operations, and thus the Parsis always came to the front. Those gentlemen who had hitherto spoken, had confined their attention to the great merchant princes, and the more prominent of the Parsi race, but he should like to say a word for the humbler classes. He had remarked, for years, the tenacity with which they pursued anything they took in hand, and to that element in their character he attributed the success and influence of the whole community. He was honoured by the acquaintance of the first Sir Jamshedji Jijibhai, and the intimate friendship of the late Sir Karasji Jehangir, and other eminent individuals, and, therefore, he had had every opportunity of forming the opinion he had delivered. Reference had been made to the fallen fortunes of many great Parsis, but look at the name they had left; look at their profuse liberality whilst they were living, not content with leaving large legacies to be given after their death. The brilliant examples they set in this direction should never be forgotten, the monuments of which could be seen in the colleges, schools, dispensaries, and hospitals they had founded. Only recently the *Times* said there were many millionaires in England, but how little you could get out of them; but if you went to a Parsi for assistance towards any good object, you got it most readily.

Mr. T. H. Thornton, C.S.I., said he had always had the greatest admiration for the Parsis, regarding them, as a community, amongst the most wealthy, energetic, loyal and munificent, and the more he heard of them, and saw them, the more he admired them. Although their numbers were small, their influence was extensive. Speaking of the north-west of India, and the Punjaub, the Parsis might be considered, in a sense, the pioneers of civilisation. Whenever a small station was established in a remote locality, there appeared the Parsi shopkeeper, and of the greatest

advantage he was to the place. He could not say that his champagne was perfect, or that his preserved fruit and pickles were always absolutely fresh, but still he was a great benefactor to society, and made many an out of the way station of Northern India comparatively pleasant and agreeable. Having listened to the account of the rise and progress of the Parsi community, he could see now how it was they had proved so wealthy. He understood that for some years they had been in the habit of earning 100 per cent. on their money, which was very satisfactory, but it was still more satisfactory to think that they made such exceedingly beneficent use of their great riches. They were not only successful as traders, but they also produced eminent shipbuilders, and when he heard of the deeds of the Wadias and the Jamshedjis in that line, he could not help thinking that in the present state of the navy it would be well if we had a few of them still. But though he admired all these excellent qualities in the Parsis, there was one point in which he was particulaly anxious to testify his admiration of them, and that was the splendid example they were setting to the rest of India in the matter of female education.

Mr. LIGGINS wished to bear testimony to the accuracy of the remarks in the paper with regard to shipbuilding. When he was a young man, he recollected on many occasions being on board some of the finest East Indiamen in the East India Docks, which were built of teak in Bombay, and fastened with iron bolts. They were, therefore, cheaper than copper-fastened boats, and equally durable, because teak had the merit of preventing the corrosion of iron. It must be easy to build very fine ships where teak was cheap; but he feared that now vessels were built of steel, it would not do to look to Bombay for shipbuilding, though he had heard an officer of the P. & O. Company state that any repairs could be as well done there as in England.

Mr. JEHANGEER DOSABHOY FRAMJEE, in reply, said that with all respect for Mr. Mowat, who had been chairman of the Chamber of Commerce in Bombay, and held a foremost position in the mercantile community there, he begged leave to point out that the authority for his figures was the report issued by the Commissioner of Customs in the present year. The figures given included the whole of the sea-borne trade, excluding the coasting trade. With regard to what had been said by Mr. Bhownaggree, he should have liked to embrace in the paper an account of the glorious past, and to show the difficulties with which the Parsis had had to struggle, and how they had overcome them, and achieved success, but in the first place if he had done so the paper would have been unduly long, and, in the second place, he was limited at the outset to the connection of the Parsis with the trade of Western India, besides which, if he had attempted any historical description of the past, it would have been only giving a second edition of the book lately published by his father, to which he had referred in his paper.

The CHAIRMAN then proposed a cordial vote of thanks to Mr. Framjee for his paper. In that he had been compelled to confine himself principally to the Parsis in their commercial relations, but he (the Chairman) might mention that they had distinguished themselves in many other ways; for instance, they had not lately been looked upon as a military race, but yet there was one old gentleman whom he knew a few years ago, who was a very distinguished native officer indeed. His name was Kursetjee Sett, and he was an officer of the Poonah Horse in 1817, and took part in the battle of Koregaon, one of the most gallant actions that ever reflected honour on the British flag and on the native army. For that service he was decorated, and for many years also did excellent service as a civil administrator. He was a man who might be considered as a typical example of what a Parsi could do in the military service if called upon. He could not refrain from again referring to Mr. Framjee's father, who was a great friend of his, as an instance of ability in civil administration. For many years Mr. Dosabhoy Framjee had been a police magistrate in Bombay, and there were very few towns in which, from the mixture of races, and the number of what might be called the rough element, sailors and others, the duties of a police magistrate were more arduous, or required more tact, temper, and knowledge of the law and mankind. He was sure he expressed the opinion of every citizen of Bombay, both native and European, when he said not only had there not been a complaint of the way in which Mr. Dosabhoy Framjee performed his functions, but that he did so with the universal applause of the whole community. He had intended to say something in reply to Mr. Martin Wood's remark on the immovability of the Parsis, but Mr. Thornton had entirely disposed of that argument, having pointed out that wherever western civilisation appeared its pioneer was the Parsi.

The vote of thanks was then put and carried unanimously.

EIGHTEENTH ORDINARY MEETING.

Wednesday, April 22nd, 1885; Sir BERNHARD SAMUELSON, Bart., M.P , F.R.S., in the chair.

The following candidates were proposed for election as members of the Society :—

H.R.H. Prince Albert Victor of Wales, K.G., Marlborough-house, S.W.
Garcke, Emile, Anglo-American Brush Electric Light Corporation, Belvedere-road, Lambeth, S.E.
Gaussen, David, Broughton-hall, Lechlade, and 8, Craven-hill, W.
Hake, George Gordon, 12, Portland-place, Hammersmith-road, W.

Schwann, Frederick, Oakfield, Wimbledon.
Scott, F. Walter, Woodcliffe-house, Burgess-hill, N.W.
Smith, Charles Ridley, 32, Nicholas-lane, E.C.
Smith, J. Fisher, 89, Piccadilly, W.
Tripplin, Julien, 5, Bartlett's-buildings, E.C.
Wilson, Francis, 109, Long-acre, W.C.

The following candidates were balloted for and duly elected members of the Society:—

Dalyell, Hon. Robert Anstruther, C.S.I., LL.D., 21, Onslow-gardens, S.W.
Hardy, G. Hurlstone, Park-lodge, East Twickenham.
Head, John, F.G.S., 12, Queen Anne's-gate, S.W.
Hodges, Herbert J., Chesterfield-house, Barclay-road, Fulham, S.W.
Kendal, James, 106, Cheapside, E.C.
Pears, Andrew, Spring-grove, Isleworth.
Stenning, Alan Herbert, East Grinstead, Sussex.
White, William Henry, Lower Condercum, Newcastle-on-Tyne.

The paper read was—

TECHNICAL EDUCATION, WITH REFERENCE TO THE APPRENTICESHIP SYSTEM.

By Henry Cunynghame.

The question of technical education is one which is daily growing into greater importance. The report of the Technical Education Commission has afforded fresh information as to the condition of technical schools abroad, and the efforts which have been lately devoted to the subject have attracted public attention at home. There is, however, one application of technical education of which I wish particularly to speak this evening, namely, its relations to the apprenticeship system.

By technical education is meant instruction in the art of applying the discoveries of science to the requirements of modern industry. It is not scientific teaching in the strict sense of the word, nor, on the other hand, is it mere craftsmanship. It is rather the application of science to craftsmanship. To take an example, the mode of treatment of electrical subjects given in the works of the late Professor Clarke Maxwell is purely scientific and mathematical; in his hands electricity is an applied mathematical science. In the hands of Faraday, electricity becomes an experimental science. But neither the teaching of Faraday nor Maxwell is of exactly the kind that is suitable for a mechanic—something more practical is needed; the body of truth must be arranged rather with a view to action than to knowledge. This requires a bent of mind that is midway between science and craft; it is the liberal part of the education of an artisan. We require manual dexterity guided by wide views, and scientific knowlege accompanied by executive power. Hence it follows that it is useless to expect the technical school to take the place of the workshop, or a technical course of instruction to replace the apprenticeship system.

How often does the engineering training given to some young gentleman result in making him a mere theoretician, an architect who cannot lay a brick, or a surveyor who does not know as much of detail as a small practical builder? And, on the other hand, how many artisans are there, of excellent practical skill, whose efforts are not guided by any scientific knowledge, and who work entirely by rule of thumb? They even distrust and dislike theory, not recognising that the true aim of theory is to classify and embody the soundest rules of practice.

This truth is seen more clearly when we read the lives of original thinkers like Watt or like James Nasmyth. Their success consisted in the art, for which, as a nation, the English are so conspicuous, of reducing theory to practice, and again of evolving theories out of practical results. So far from theory being opposed to practice, no great success can be achieved without an intimate union of the two, and no rule is safe, nor result sound, unless both are blended into harmonious union. Here is the true aim of technical education.

In the report on technical instruction of 1884 (vol. i., p. 538), it is recommended not only that charitable endowments be applied to technical instruction, but even that local authorities should be empowered to establish, maintain, and contribute to the establishment and maintenance of technical schools and colleges. This recommendation is calculated, and with reason, to alarm the mind of the already burdened taxpayer. He may well ask whether, having undertaken to educate all the children in England in the three R's, he is in addition to be saddled with the expense of teaching every artisan his trade. And when the enormous expense of technical instruction is considered, as displayed in the details of the two volumes of the commission, the ratepayer may well shrink from the prospect.

It is, therefore, incumbent on the friends of technical education to consider how it may be most economically carried out; and I believe it will be found that the solution of this question lies, not in attempting to replace workshop training by classes or lectures, but

rather to supplement it by theoretical intstruction. And the best time of life to do this is during the period when the mind is most receptive, namely, during those years in which the artisan is serving his apprenticeship.

It is often rather hastily said that the apprenticeship system is dead. I think that nothing is a greater mistake. I believe that if careful inquiry were made, it would be found that most good artisans have been apprentices, and that the greater part of boys now learning trades are serving five or seven years. But there is a great difference between the apprenticeship system of to-day and that of the past. In former times, the apprentice was usually an inmate of his master's house, who boarded, lodged, and clothed him. Now, the boy in general lives with his parents, or else with some relation or friend, generally paying for his keep, at least in part, out of his earnings.

Moreover, the spread of handicraft literature has almost destroyed trade mysteries or secrets, and the result is that, in the greater number of trades, no premium is now required from a boy on his going into articles for seven years. On the contrary, he generally begins with low wages, averaging apparently about 5s. per week during the first year, and rising to 15s. or 18s. per week during the last.

The strictness of the system depends greatly on the nature of the trade. For instance, in those trades which are not greatly subject to foreign competition, trade societies are usually powerful—as, for instance, the bookbinding trade. Most of the shops or factories in these trades are society shops, and therefore it is exceedingly difficult for a workman to obtain employment unless he has served his term of apprenticeship, and his articles have been duly *visé*d by the officers of the society.

In other trades, such as clock and watchmaking, the competition from France, Switzerland, and America is so formidable, that the societies have but little power, and hence the apprenticeship system is laxly administered.

Now, I think that all attempts at technical education will be imperfect that do not, to a certain extent, deal with the apprenticeship question. It is in the workshop that the artisan must be really formed; just as the barrister must be trained in chambers, or the doctor in a hospital. At the same time, what the university is to the advocate or medical man, the technical school should be to the artisan; only, however, with this difference, that it is generally necessary that while he is learning the artisan should be also working, and that his technical instruction should go on contemporaneously with his workshop employment. At present, considerable sums are yearly spent out of charity funds in paying fees on indentures. With some exceptions, I believe that money so spent is almost wholly thrown away. Since the masters are, in most trades, willing to take boys without a fee, the payment of the fee only enables the charity trustees to bargain with the employer for higher wages for the boy, and thus to cause the fortunate inhabitants of some ancient precinct or parish to secure one or two shillings per week pay more than their fellows in the same shop—a result which, it must be admitted, is not desirable.

Moreover, under the present system, sufficient care is not taken to select for the boy a trade that is suited to his ability. Indeed, under the present system, this is impossible. He is asked by the trustees, or by their clerk, what trade he would like. Now, it is notorious that boys have the very vaguest ideas of what they desire. Some tale by a friend, or some story in a boys' journal, supplies them with a picture of life, and in most instances they only ask for a light trade and a kind master. The articles are then signed, and the money paid, and the seven years' contract is irrevocable. In too many instances, the boy only finds that he has embarked in a career that he dislikes, and the master that he has got an unsuitable apprentice.

Moreover, under the present system, the boys are not sufficiently looked after out of work hours. Whatever may be our opinion of the undesirability of over-parentalism towards men, there is no doubt that it is good for boys to feel that there is someone who has authority over them, and who desires their welfare, who takes an interest in their work, and who will endeavour to rescue them if they fall into dissolute habits. No one who has witnessed the work that the late General Gordon did among the ragged boys of the suburbs of the East of London can ever underestimate such influences. To exercise such supervision has ceased to be the master's duty, and now it is left to chance. Hence it is that anyone who will visit the lower and cheaper music-halls of London will find them crowded with apprentices about seventeen years of age. Here it cannot be said that their taste is improved, or their habits of sobriety encouraged, and here too often they form friendships which lead them into extra-

vagance and idleness, and often connections with the other sex that are immoral and undesirable, and end by producing lives of misery for others besides themselves.

To counteract the evil I have spoken of, there appears to me no more useful plan than to form youths' institutes. The duties of the officials of these institutes should be to see to the apprenticing of boys, encouraging them to enter such trades as offer good prospects, and endeavouring to guide their choice. In all cases a month's trial without pay should be insisted on, and free liberty given to master and boy to refuse the proposed contract at the end of the time. There is no fear that, under such conditions, a boy will desire to change too often.

At such institutions lists should be kept of masters desiring hands, and of boys desiring to learn trades. The character of the masters should be carefully investigated with a view to ascertaining whether they are fit and proper persons, or whether they have lately been bankrupt, and are likely not to be able to fulfil their engagements.

Moreover, the boys should be periodically inspected, a monthly report being given by the master respecting their conduct; and, on the other hand, steps taken to compel the masters to stand fairly by their side of the contract.

It may be a matter for question whether the Society should aid a master in punishing an apprentice who runs away or steals. At present, when an apprentice breaks his articles, few masters will take the trouble to prosecute him, and hence is laid the foundation for the idea, so prevalent among all classes of mechanics, that no working man is to be considered in any way bound to a contract. This is a source of constant loss to masters, and results in lower wages to men, and nothing would counteract it so effectively as to force boys, from their earliest years, to see that if they make a contract they are to be bound to stick to it.

I do not believe that it will be necessary or beneficial to pay the apprenticeship fees out of charity money. Quite sufficient aid would be given by lending it, subject to gradual repayment, say, of 6d. per week out of weekly wages.

Such institutions should be closely connected with, and form part of technical schools. Most of the classes would naturally be evening classes, and the subjects so chosen as to be useful to the boys in their various trades. And it would undoubtedly much conduce to the efficiency of such institutions if a certain number of working men could be placed on the committee, to give the benefit of their experience, and to inspire the boys and their parents with confidence.

During their apprenticeship, the boys should be encouraged to exhibit proofs of their skill, for which prizes and exhibitions should be awarded; and one of the best forms that scholarships could take would be the setting free of the industrious boy for a few more hours a day, in order to devote the time to study at the institute. Periodical exhibitions give a boy pride in his work, and encourage the feelings of enthusiasm with which the apprentice in older days was wont to regard his "masterpiece."

And, to my thinking, the technical school should not stop here. Amusement and exercise are as needful for boys as instruction; and while it would not be right to spend either money given by charity or raised by taxation in providing amusements, still institutions such as I have named might lend spare rooms or yards for gymnasia or recreation purposes, or might provide baths and refreshment rooms, where tea and coffee, or even dinner, could be got, but so always as in these respects to be self-supporting. A public library available for all classes would be a useful adjunct.

The above scheme may perhaps seem very extensive, but it is no more than I feel persuaded can be done without an extravagant cost, provided economy is carefully studied.

Moreover, a system akin to this is now in operation with the best results, in the excellent charity organisation in the East-end of London managed by the Jews. They have unusual difficulties to contend with, owing to the boys, from religious reasons, not being able to work on Saturday; and yet they have so arranged matters as to make the apprenticeship system adopted by them almost self-supporting.

And this leads me to lay before you a few considerations upon the expense of technical education. In such institutions scientific apparatus is a necessity.

It behoves, therefore, the friends and advocates of technical education to endeavour to discover whether the cost of this apparatus cannot be so decreased as to bring it within the reach of the masses, for certain it is that if technical instruction is so costly as it has hitherto proved, it is not to be expected either that the working classes should pay for it, or that the expense should be inflicted upon the public.

Every amateur who has dabbled a little in science, no less than every man who has made it his profession, knows the expense of scientific instruments. If he wants to measure the length of a wave of light, there is a bi-prism to be bought, mounted in its stand of polished brass, with a parallel slit in another similarly polished stand, a collimating lens, and a similarly mounted telescope, which, added together, make up a pretty heavy sum when purchased from one of our instrument makers.

But people are not sufficiently aware, because they have not been taught, that as far as the verification of the theory of light goes, such wave lengths can be measured with all the accuracy that educational purposes require, with a small piece of a visiting card, a piece of fine wire gauze an inch square, and a two-foot rule, total cost, say, 1d.

In the same way, a spectroscope can be made out of paper tubes, cheap lenses, a few pieces of glass, and a little bisulphide of carbon, at a total cost of, say, 5s., which will divide the D sodium line in a manner quite sufficient for the instruction of mechanics. Instances of this kind might be multiplied indefinitely.

There is no scientific instrument of any sort which cannot be made to serve for educational purposes, at a cost of as many shillings as it now costs pounds. But such a mode of study and teaching requires certain rules to be rigorously adhered to. In the first place all lacquer, French polish, ornamental paint, and varnish, must be strictly discouraged, and even forbidden. The students must be taught not to spend one moment on ornamentation of any kind. The one aim must be accurate fit and adjustment of essential parts, and absolute indifference to all others. This rule is harder to enforce in practice than might be imagined. When a new microscope comes home from the maker's, its polished mahogany case is opened, and, to the eyes of the beginner, a vision of splendour is revealed in the golden gleam of the shining lacquered brass. All this he must studiously avoid. It is the mere joy of a child in a new toy. His only care or thought ought to be whether the lenses are optically true and achromatic, and, with these conditions satisfied, he should be carefully weaned from the prejudice in favour of varnish and veneer.

I saw, lately, a spectroscope by a leading London firm. Nothing could be more elegant than the finish and polish of the brass, but on investigation the axis was found too short, and not truly in the centre of the dividing plate, and the tube of the collimator was actually half an inch too long. A better result could have been obtained with some pieces of wood and cardboard than with this forty-guinea instrument. If half the time spent in polish and lacquer had been bestowed on accuracy in the essential parts, the instrument would have been worth double the money.

The first benefit of the adoption of the system of making the students construct their own apparatus is, therefore, economy. All that is needed is a store of flat glass, glass tubing, wood of different sizes, brass discs, screws, wire, and various chemicals, and a few simple tools, such as a fine tenon saw, pliers, and a few files, while, for general use, a glazier's diamond, a grindstone, and a large dividing protractor and steel scale, a pair of accurate balances, and a few such apparatus, should be in every laboratory.

The comparative list in page 631 will show, as an example, corresponding sets of instruments. In the second column is placed the price as usually charged by a good instrument maker; in the third, the price at which an equivalent instrument can be constructed by the student; in the fourth, the time a skilful workman would take to make the instrument and adjust it. (Of course beginners would take far longer.)

On the table I have here a set of tools and chemicals with which many of the apparatus here before you were made, and which is amply sufficient to make all that are given in the above list. The cost of the whole comes to £6 10s. The details are given on a card placed on the table. In this way a sum of £20 would go far to set up a technical class with the necessary tools and appliances, while if it were desired to do more elaborate work, the addition of a lathe, bench-vice, set of drills and other simple tools could be made for about £60. But not only is economy consulted by this system of teaching, the instruction is far more efficient. Suppose, for instance, it be desired to exhibit the qualities of polarised light. Whether will it be better to buy a shop-made polariscope with all the adjustments already made, or to cause the student to place his reflector at the true polarising angle, to secure it there with neat pieces of cork and sealing wax, to place his bundle of microscope glass plates in a tube, again securing the proper angle of inclination, and to tinker up the instrument till it works, at an outlay for materials of, say, a

	£	s.	d.	s.	d.	Hours
ELECTRICITY.						
Thomson's reflecting galvanometer	10	10	0	8	0	12
Ordinary galvanometers	1	17	0	2	6	6
Tangent galvanometer	3	0	0	2	6	4
Resistance coils	2	10	0	4	0	9
Lamp and scale	0	15	0	1	6	1½
Magnetic needle	0	2	6	0	1	½
Set of magnets	0	1	6	0	2	¾
Thermopile	0	17	6	0	8	2
Four battery cells	0	6	0	0	8	1½
Magnetometer	1	1	0	0	2	2½
Small portable do.		?		0	1	¼
Induction coil and condenser	0	10	0	4	0	5
Electrophorus	0	5	0	2	0	2
Leyden jar	0	2	0	0	8	1
Condensing electroscope	0	3	0	0	1	1½
Dry pile	0	5	0	0	6	1½
Quadrant electrometer	10	0	0	3	0	15
LIGHT.						
Spectroscope	5	5	0	5	0	8
Wave length measurer		?		0	1	½
Liquid prisms	0	15	0	0	6	¾
Refraction measurer	5	5	0	1	0	4
Polariscope	2	10	0	1	6	2½
Concave and convex mirrors	0	4	0	0	4	1
Telescope*	2	10	0	2	6	8
Photometer	0	5	0	0	2	½
Spirit level	0	1	6	0	2	½
SOUND.						
Monochord and weights	1	10	0	0	8	3
Glass tube for dust figures	0	5	0	1	0	2
Telephone	0	6	0	0	6	1½
Microphone	0	5	0	0	4	1
HEAT.						
Expansion machine	1	0	0	0	8	2
Differential thermometer	0	5	0	1	0	2
Alcohol thermometer	0	1	6	0	3	2

* An excellent lecture on "How to make a Telescope for 2s. 6d.," was lately given to boys by Professor Norman Lockyer.

shilling? Which of two students will use a really fine instrument the best, one who has been trained in the manner here advocated, or one that has always been provided with instruments ready made?

It must be remembered, too, that this course has always been followed by the great discoverers. We read of Newton discovering the shadow fringes of light, by means, as he tells us, of two pointed knives ground flat, and with their points pricked into a board. He misunderstood the causes of the phenomenon, but Fresnel afterwards discovered and explained them with no better apparatus than some pieces of cardboard and sewing thread. Mr. Justice Grove's first battery consisted of a wine glass, a tobacco pipe, and some bits of metal.

It is not sought here to depreciate accurate instruments. For purposes of measurement by an observer engaged in original research, no refinement can be too delicate, no mechanism too good, but the path of the student should be upward towards these things though a course of study with self-made apparatus.

Moreover, such construction teaches the learner the use and nature of materials. You may, perhaps, remember the construction of a reflecting galvanometer if it has been taught to you—perhaps you may forget it; but if you have once wound a coil with 3,000 turns wrong, and had to unwind it, we may certainly count on your not doing so a second time. If you have cemented a liquid prism with marine glue, and filled it with bisulphide of carbon, you will not probably repeat the error.

The neat use of blowpipe, the handling of heated glass, the use of paraffin wax for the countless purposes to which it is applied in the laboratory, are of themselves an education of the highest value, not only to those who are to be engaged in original research, but also to those who are to become foremen or artisans. But it might be, perhaps, objected that the method consumes too much time. This, of course, would greatly depend on the teacher. It is not proposed that a student should make every conceivable piece of apparatus. For instance, it would be absurd to expect him to try and rule a diffraction grating. And, again, his instruction will be supplemented by daily lectures, at which more elaborate experiments will be performed by the professors. It is, however, always found that all knowledge takes time to penetrate, and as it were to suffuse the brain, and while the fingers are working the mind ought to be thinking.

It may further be asked whether such a system as is here advocated has ever been tried, and with what results. The answer to this is that such a system has been, and is being, practically worked in a few places, and it is much to be wished that it were greatly extended.

The merit of practically applying, if not of inventing this mode of instruction, is probably due to Professor Guthrie, of the Science Schools, South Kensington, and every year in the summer teachers are taught in this manner how to teach. At the end of the course an industrious student will go away armed with a whole cabinet of scientific apparatus (for the

apparatus becomes the property of the pupils who make them), and with this he would be able easily to teach a school. In technical schools, wherever practicable, it should be made a condition of appointment that at least the assistant demonstrators and lecturers should be able to use their tools well.

Too much pains cannot be taken to inculcate this system. Let prizes, if needful, be given for the simplest and cheapest apparatus which shall secure a result of a certain specified degree of accuracy, and encouragement of this kind will speedily provide a scientific set of apparatus in every village school.

Therefore I urge that it is time that if technical education is to be widely spread, it should take the form of a system, that rigorous economy should be practised, and while no salary is grudged to a competent professor, he should be required to work with cheap materials. The problem is not so much how to do it, as how to do it cheaply.

When, however, we reflect on the splendid ability that is in this country being devoted to technical education, when we read the names of the professors at the great educational establishments scattered over England, we must certainly feel that we have ample guarantee for the solution of the problem.

Moreover, these establishments are on the increase. Not to speak of the Finsbury Institute, there are several smaller ones which are well worthy attention. The Horological Institute in Northampton-square, aided by a small grant from the City Guilds, is doing admirable service; and the munificence of a private gentleman, Mr. Quintin Hogg, has provided an institution which now numbers 3,000 youths as members, 2,000 of whom attend evening classes, which are also attended by 4,000 more youths who are not members of the institute. By this institution, which occupies the site of the old Polytechnic, 7,000 young men are benefited, and provided with physical and mental training and recreation, and assisted in keeping out of mischief. I believe that the original outlay did not exceed £30,000, and that the yearly total cost of maintenance is about £7,000, of which a large part is covered by the fees and subscriptions.

To attempt, at public expense, to do what can only be done in the workshop, is a mistake, it will fail in its results, and it is unjust to expect the nation to pay for it, but it has been endeavoured to show, first, that in attempting to improve technical education, some attempt should be made to deal with the apprenticeship question; and, secondly, that at an almo[st] nominal expense, and by the application [of] a proved method already in use, practic[al] technical science may become a part of t[he] education of our town and rural population.

It need only be added that it is high[ly] desirable to make the boys and their paren[ts] pay, as far as possible, for the benefits th[ey] receive, and no money is such an excelle[nt] investment of capital as that which is wise[ly] laid out in education.

DISCUSSION.

Dr. GLADSTONE, F.R.S., agreed with the reader [of] the paper that this question was one of primary impo[rt]ance. Whether the system of apprenticeship s[hould be] continued or not, there was no doubt that it was l[ess] common than it was formerly, and that in so[me] trades it was dying out. In any event, techni[cal] classes were required, for though he held that [no] trade could be learned except in the workshop, st[ill] those would make the best of the instruction giv[en] them in the workshop who had had a certain amou[nt] of theoretical foundation laid beforehand. The[se] classes might be formed in various ways, and [an] excellent example had been referred to in the ca[se] of the Polytechnic Institution, where so ma[ny] students were being well taught various matte[rs] which would be of great service to them in conne[c]tion with their handicrafts. He did not think it w[as] desirable to teach trades in the elementary school[s;] what should be taught there should be what wou[ld] be useful to all the scholars, not to a portion [of] them only. People were gradually working up [to] this idea, but still vaguely. Many wanted somethi[ng] definite in the shape of carpentry or iron workin[g,] and seemed to think this was the true kind of techni[cal] education; but it should rather be their aim to gi[ve] such a notion of the value of materials and the u[se] of tools as could afterwards be turned to use in a[ny] required direction. There were two great difficulti[es] in the way of doing this in elementary schools. T[he] first and greatest was the inveterate notion th[at] education consisted of "book-learning. No doub[t] centuries ago, when education was the privilege [of] the few, and schools were intended mainly for tho[se] who were to enter the professions, the chief part [of] education was of a literary character; but now th[at] education was become the right of the masses [of] the people, the problem was entirely altere[d.] Children should be taught that which would be mo[st] useful to them in after life; they should not be train[ed] for professional men, or even for clerks. No doubt th[ey] should have that simple kind of literary educati[on] which would make them all clerks, because me[re] clerkship ought to be the lowest kind of work; b[ut] beyond that, they should be encouraged to devel[op]

some kind of skill. It was very difficult to get over this kind of prejudice in favour of a literary education, and while it lasted, the knowledge of science and the arts would not take their right position. Another difficulty was the ignorance of teachers in this respect. If an endeavour were made to introduce some knowledge of science into schools, they generally found that the teachers had some kind of theoretical knowledge, but it had been obtained mainly from books; and what was chiefly wanted was that things should be taught as well as words, and before words. He did not say things only; they wanted *res et verba*, but the *res* must come before *verba*. Pupil-teachers had to give object-lessons, but they were not taught or examined in this subject. This was one of the greatest wants in connection with the system of education. Some of these difficulties, however, could be and he hoped were being overcome. The idea that education must consist in the teaching of literature was giving way, and subjects of fictitious importance, such as spelling, and good pronunciation, would, he hoped, soon be considered less material; whilst a knowledge of the world in which we lived, the forces with which we had to deal, and the materials which must occupy the attention of the great mass of the community, would attract more attention in future. Some of these difficulties might be got over by the peripatetic system of teaching science which was employed in Liverpool and Birmingham with great success, and he was glad to say the London School Board was about to introduce it experimentally. In one way or another he trusted the desired end would be reached, and that the long-suffering ratepayer would have more for his money than he had hitherto, and that the next generation would grow up more capable of doing the work of the world.

Mr. B. LUCRAFT regretted that he could not agree with Mr. Cunynghame in his view of the present state of the apprenticeship system. His opinion was that there was scarcely a good firm in London who would take apprentices. An employer wanted to get his work done as quickly as possible, and would not be bothered with apprentices. He should like to see, in place of the apprenticeship system, and with a view of preventing all the clever boys in London turning their attention to clerkships, scholarships given in technical schools with a workshop attached. At present, most of the clever boys went into the Post-office, or a place of that kind, for he found that nine-tenths of those who won prizes, when asked as to their future career, expressed such an intention. Some of the scholarships now given to clever boys were, he was sure, an injury rather than a benefit to them. If institutions were established where the whole theory and science applicable to certain trades were taught, combined with workshop instruction, a class of artisans would be raised up superior to any which could be obtained in any other way. The apprenticeship system in London was almost done with. He worked in workshops, and most of his acquaintance did the same, and they had the greatest difficulty in getting their sons apprenticed in any way. Some employers would take a boy, and give him so much a week so long as he behaved himself, but they would not take apprentices. Boys trained in such an institution as he had referred to, learning both theory and practice, would become overseers and foremen, and ultimately masters. He gave evidence on this subject before the Royal Commission, and suggested that some of the City endowments which were left to encourage trade might be devoted to such purposes which would be quite in accordance with the views of the original donors, though carried out in a way more suited to the present time.

Mr. G. N. HOOPER said this question was now moving a little, though not fast enough in the opinion of many who were interested in it. In the first place, the Council of the London Chamber of Commerce passed a resolution, about a fortnight ago, to support and make known the benefits which would result to trade and commerce by a further development of the system of trade education; and, secondly, on Friday next, a meeting would be held by the Artisans' Technical Institute, at which Mr. Woodall would preside, when both employers and workmen would be present to consider this question. This was a step in the right direction. The subject had been treated by scientific teachers, and by the City Guilds, many members of which were not practically connected with trade, and it had not been so favourably received by manufacturers as if they themselves and their workmen and foremen had been more consulted. As chairman of a technical class, he had seen excellent work done at an expense of less than £100 a year, the class averaging 40 to 50, and some who had passed through the course had done remarkably well, and would exert an influence on their trade which could not fail to be beneficial. Some people thought that technical education must be extremely expensive, but that was an error. There were a large number of school-rooms which were totally unused after dark, and they might be made available for this purpose, at a small expense for cleaning and lighting. As one of the jurors at the Paris Exhibition of 1867, he found the French were making considerable advances, and he followed up the matter by visiting the schools, and becoming acquainted with the teacher and the students. On the first opportunity, he had sent a suitable man over to Paris to be trained, and having had previous instruction in science, drawing, and manual labour, he was able to take full advantage of the opportunities offered him, and since his return had been very useful as a technical teacher. A second one had since been sent, and thus the method of teaching usual in France had been transferred. A few days ago, in the *Chamber of Commerce Journal*, there was a quotation from the *Bourse Lyonnais*, showing that the

French were dissatisfied with the progress they were making compared with other nations, and stating that in Germany upwards of 100,000 workmen were passing through the technical classes. But these facts did not come out very often. During the last Paris Exhibition he attended a meeting of a group of syndical chambers, and took notes of the discussion, but the President afterwards requested him to give these notes to him, saying it was not permissible to take away any record of the proceedings. That, perhaps, might account for the fact that they did not hear much of what was going on in foreign countries; but the manufacturers in this country were beginning to feel the pinch. The most efficient teachers were found to be properly trained artisans who had studied the sciences applicable to the occupation they followed. Difficulties were often met with in practice which no mere professor could get over.

Prof. GUTHRIE, F.R.S., said he only claimed a part of the merit which had been attributed to the work which had been going on for ten years in the Science Schools at South Kensington, though he was responsible for it, for he had been most ably supported throughout by the demonstrators, whose assistance it had been his good fortune to secure. When he first entered on the work, he found that the teaching of physics in this country was almost purely theoretical; and having been trained as a chemist, he reflected what sort of a chemist that man would be whose training had been derived entirely from the lecture theatre and from books; and the question occurred to him, could not elementary physics be taught practically. Then it came to a question of expense, because he had to teach teachers. So it became necessary to devise a system, a sketch of which had been given in the paper, of getting typical apparatus for showing the elementary principles; it had to meet the wants of the teacher; and it must be absolutely and scientifically correct in principle. Mr. Cunynghame had spoken rather too slightingly, he thought, of some of he instruments, saying they did not reach the accuracy attained by an ordinary instrument maker; but he should say that such apparatus as was shown was far more scientifically and absolutely accurate than that which would be produced by the ordinary optical instrument maker. It was simple in construction, but truthful in conception, and without any adornment. This method of bringing the hand and the mind to work together really lay at the basis of all true technical instruction; where the mind alone was employed, the knowledge acquired passed away, but when the mind and the hand had been educated together, the knowledge was never forgotten. For the last ten years his life had been devoted to the development of this particular branch of knowledge, and he could not understand its being so little known and appreciated.

Sir FRANCIS SANDFORD said he was not a scientific man—having been born in the pre-scientific age—but he was very thankful to Mr. Cunynghame for the excellent lesson he had taught him and his colleagues on the Royal Commission, as to what they were to do with the money at their disposal in future. They had already made a great step in the direction advocated by Mr. Lucraft, for it was proposed to devote many thousands a year out of the funds of Christ's Hospital to the establishment of a large technical school in London; and they intended to model it on the Allan Glen school in Glasgow. That was established largely by one who, like himself, was not a scientific man. The Scotch Charity Commissioners intended to do the same with some of the funds belonging to Heriot's Hospital, Edinburgh, and to establish a technical college which they hoped would rival the establishment at South Kensington. He had for some time ceased to have any influence in the Education Department, but he had some share in introducing the teaching of science into elementary schools, and was glad to see that in the new code drawing was made an essential.

Mr. E. C. ROBINS said the impression left on his mind, by visiting the technical schools in Germany was that the difference in the education of the two countries lay rather in the sections of society above the artisan class, and that the middle classes in England were most backward with regard to scientific education as compared with the Germans. All our schools were practically literary; they were not divided into polytechnic and real schule, and even science was taught more from the literary side, and less awards were given for it. He was astonished to find that so many of the working classes were profiting by the advantages offered them as Mr. Hooper had stated, but if it were true that information was not readily obtainable, that might account for the general ignorance on this subject. If foreigners were making such progress, it was all the more important that England should wake up to the importance of the matter; and, as an architect, he might say he found very few men who had passed through such a training as enabled them, properly, to execute the work they were called upon to undertake. He knew one large firm in the West-end where there was not a single apprentice taken. Another large firm a little way out of town employed chiefly apprentices, and some years ago, when a strike took place in the building trade, they were able to carry on their works without any trouble in consequence. There was a great difficulty in this country in getting proper instruction for youths entering the building trades; it was a favour to get them into a shop at all. He thought the trades' unions, if they were worth anything, ought to see to this; but, on the contrary, he understood they rather set their faces against apprentices, and seemed only to think of getting as much money as they could out of the master, and of giving as little as they could for it. He had heard that stated, broadly, by a representative of a trades' union at a public meeting, much to the

astonishment of everyone present. There was a great fright with regard to technical education, on account of the expense involved in teaching apparatas, and he hoped this paper would do some good in helping to remove that impression. To that end he would suggest that the simple apparatus exhibited should be photographed, so that the idea that nothing could be done without expensive appliances might be exploded.

Mr. WILLIAM TRANT (Secretary, Artisans' Technical Association) said the reader of the paper seemed to make a great point that a certain piece of apparatus which took fifteen hours to make only cost 4s. 6d. He did not know whether he meant to convey that technical education would enable people to work for less than 4d. an hour, but if so, that would not meet the views of artisans. All were agreed that technical education was a good thing, and almost all were agreed as to the mode by which it might be carried out; but with regard to the question of apprenticeship, there was much more room for discussion. Mr. Robins seemed to think trades' unions were very much at fault in this matter; but he would remind the meeting that they were not altogether to blame. They had found hitherto that they had to teach the apprentices for the benefit of the employers alone; and not only that, but that they enabled the youths to enter into competition with themselves, and thus the feeling naturally arose that they were cutting their own throats. The rapid improvements in machinery and other things had really revolutionised the system. Apprenticeship as it formerly existed could no longer be maintained, and they had now to consider how youths were to be trained in their respective trades The question was whether some responsibility did not rest on the employer, and also on the Legislature, to see that lads who were apprenticed should be turned out skilful workmen. The committee which was to meet on Friday, to which Mr. Hooper had referred, would have to specially consider this question. Allusion had been made to lads who ran away from their work, and ought to be compelled to go back. It seemed to him that was just the way to make bad workmen, for unless they had a dislike to the trade they would not leave it. He agreed with what had been said, that the best persons to teach were those who understood the trade itself, and who in addition had received a scientific training. Such men were always looked up to and respected by the students, and produced the best results. As much as possible should be taught at school, and he wanted to see how technical education could be given before it was known what trade a boy was going to adopt.

Mr. C. R. WHITE suggested that it would be well if the money which had been left for the purpose of apprenticing boys were devoted to purposes of technical education. Visiting an industrial school some time ago, he found all the boys were taught was chopping wood, and he thought they might be much more usefully taught some trade by which they could earn a living. It also seemed to him a great mistake to keep boys several years on board a training ship, and then put them ashore instead of sending them to sea.

The CHAIRMAN said the account just given of industrial schools was certainly not universally applicable. He had been particularly interested in seeing the Artane Industrial School in Dublin, where several trades were excellently taught, and he believed, and should be glad to hear, that the same thing was done in England. The endeavour of Mr. Cunynghame to show how apprenticeship might best be combined with technical instruction was of great value, whether they agreed with his conclusions or not. He believed him to be right in saying that the technical school could not take the place of the workshop, for experiments made in this direction in various countries had not proved very successful. There was the school, which was very much praised, of the Boulevard de la Villete, in Paris, which was visited by the Commission of which he was chairman; the expense was enormous, and the results were certainly not satisfactory to their mind. Notwithstanding that, similar schools were being established in Paris, and he could only say he was glad the experiment was being made on the other side of the channel. He did not believe that artisans and manufacturers distrusted theory to the same extent as formerly, but, on the contrary, it was more understood that theory and practice must go hand in hand. At the same time, if it was necessary to choose between theory and practice during the time which a boy had to spend in learning his trade, practice should have the preference. There the Germans seemed to make a mistake; they kept the young men, especially of the higher grades, at the Polytechnic School to the age of 22 or 23, and when they entered the workshop to begin their practical training they were, especially from the excessive attention paid to the higher mathematics, unfitted for it. He was glad to hear that Sir F. Sandford approved of the introduction of drawing as a class subject into the new Code; in his opinion it was more important that a boy who was to be an artisan should learn to draw than that he should learn to write. Drawing not only trained a man to represent correctly what he had seen, but it forced him in the first instance to observe correctly, and no quality could be more valuable to an artisan than that of accurate observation. They would all be glad to hear from Mr. Trant that employers and employed were about to discuss the question of apprenticeship, but he did not think it was a matter in which the Legislature could interfere. It seemed to him a shortsighted policy on the part of artisans to discourage apprenticeship; if they felt an interest in the pursuit in which they were engaged, they could not evince that interest better than by training up good men to follow after them.

Besides, many of them were fathers of families, and it seemed to him that, by an interchange of services in this way, the whole of their class must be benefited. He felt bound to say a word in praise of the good work in which Mr. Quintin Hogg was engaged; he believed the amount he had expended was nearer £80,000 than £30,000, but at any rate the work was a most excellent one, and he had devoted his whole life thoroughly to it. He was also glad to hear what was proposed with regard to Christ's Hospital, and a better model than the Allan Glen's School could not be found. It was carefully examined by the Commission, and he was prepared to say that no more practical system of technical education for boys of the age received there was to be found in Europe. He was extremely glad to hear that the Horological Institute was so successful; a school of a similar kind at Besançon was not by any means a success, nor was a similar school lately started in Paris, there being only twelve or eighteen students in the latter. No material impression could be made on the trade at large by a school of this kind, which was only adapted to those who could expend a considerable amount on the training of their children. What could be done was to encourage apprentices to combine with their practical training theoretical instruction, and of that he did not know a better example than the school which Mr. Wiliam Mather, of Salford, had established in connection with his own works. By the introduction of such schools into workshops, or by the combination of several masters whose workshops were not sufficiently large to enable them to do the work alone, or by encouraging the youths to attend technical schools, like that at Manchester and Oldham, which had been supported liberally by Messrs. Platt, the great work of technical education would best be forwarded. He concluded by proposing a hearty vote of thanks to Mr. Cunynghame.

Mr. Cunynghame, in reply to Mr. Trant, said he had not included anything for time, but only for materials, in the figures he had given of the cost of apparatus. The value of the time would be difficult to estimate, as the students' time would be worth nothing, while the professor's would be worth a great deal. In some trades he believed it was true, as Mr. Lucraft said, that the apprenticeship system was practically dead; in the building trade it was very rare indeed, but in the bookbinding trade all the best shops in London were society shops, where no man was allowed to work unless he could show seven years' indentures properly discharged, and with the mark of the Bookbinders' Society upon them. He hoped that some of the societies which were inquiring into this subject would endeavour to obtain statistics, without which their knowledge could not be exact. He had tried to get them from Mr. Quintin Hogg's schools, having asked numbers of the boys if they were apprenticed, whether they paid any premium, and so on, and in the majority of instances he found they were apprenticed. A single person, however, could not obtain full information on this point; it must be the result of organised inquiries. If they were to replace the apprentice system by industrial schools, as Mr. Lucraft proposed, was it only to be for the benefit of clever boys? If so, what was to be done with those who were not so clever? and if it were to extend to all boys clever or not, the expense would be so enormous that it would be impossible to carry the scheme out on a large scale. They must do something cheap, as well as they could, and it had been his endeavour to show that a great deal could be done very effectually, and at a small cost.

Miscellaneous.

LABOUR AND WAGES IN THE PROVINCE OF SMYRNA.

By S. Stab, Cor. Memb. Society of Arts.

In former times, when communication was a slow and expensive process, Turkey, like many other countries, was self-supplying, namely, the people produced adequately to their wants; but when intercourse became more frequent and cheaper with England, native industries gradually died out; however, *tempora mutantur, et nos mutamur cum illis.*

Of all the large industrial centres in this Empire, excepting Constantinople, there is no place where, properly speaking, a resident labouring class, dependent on its daily work for a livelihood, has taken root as it has at Smyrna within the last quarter of a century. This is mainly due to several active influences which have been at work, and no doubt have contributed towards that end. These influences were, firstly, the introduction of railways in the country by the English, and afterwards the gasworks and the quays or embankments; secondly, the vicinity of the Archipelago. The first created a good market both for skilled and unskilled labour, while the intelligent and hardy islanders living on a poor soil, as well as numbers of Armenians and Turks from the interior, were ready at hand to supply the want. Thus by finding permanent employment, the basis for a labouring class was laid which went on augmenting, and with it sprung up fresh industries, among which I may mention a number of mechanical and engineering shops where machinery of every kind is not only repaired, but manufactured. It is noteworthy that the engines for the first steam flour mill erected at Tiflis, the capital of the Caucasus, have been entirely made here. It is not less remarkable how certain industries have developed with the increase of population. In 1870, about 40,000 pieces of muslin were annually used for making tangibs and mulls; the present consumption is 300,000 pieces of 20 yards each, all imported from Manchester. The develop-

ment of this industry, of which Switzerland had almost a monopoly in this market, is due to the firm of Aghadjanian Brothers, who being in that trade, seized the opportunity when the influx of the Turkish refugees begun after the Turco-Russian war. These poor people were ready to work at any price in order to get a living; the consequence is, that Switzerland can no longer compete with the native manufacture. In this last industry alone over 1,000 people are permanently employed. The two English railways, the English gasworks, several steam flour mills, saw mills, ginning factories, cotton, wool, olive oil and liquorice root presses, as also the foreign and local steam navigation, now provide work for a large resident labouring population. Hence it may be of some interest to show the ruling prices of labour and the cost of subsistence.

NATIVE MALE AND FEMALE LABOUR, AND THEIR NORMAL WAGES PER DIEM OF TEN HOURS' WORK.

Specification of Occupation.	Piastres.	Average.
Masons, house painters, house carpenters, and plumbers ...	15 to 20	17½
Labourers for the above	6 ,, 10	8
Mechanics working in mechanical shops	15 ,, 30	22½
Apprentices ditto	5 ,, 10	7½
Tailors, shoemakers, and cabinetmakers	12 ,, 8	15
Tangib and mull factory operatives, men	6 ,, 18	12
Ditto, women*	3 ,, 5	4
Ditto, children	2½ ,, 4	3¼
Tinsmiths	8 ,, 18	13
Stevedores	20 ,, 25	22½
Compositors (per week)	60 ,, 120	90
Railway platelayers	10 ,, 15	12½
Domestic servants, in addition to food, males (per month)	100 ,, 150	125
Women servants ,,	50 ,, 120	85
General and agricultural labourers in the vicinity of Smyrna	10 ,, 12	11
Agricultural labourers in the rural districts, in addition to food, males	6 ,, 8	7
Ditto, female	4 ,, 5	4½
Fruit packing, men	10 ,, 20	15
Ditto, women	5 ,, 10	7½
Vallonea cleaning, men	7 ,, 12	9½
Ditto, women	4 ,, 8	6
Dressmakers	10 ,, 20	15
Tailoresses and seamstresses ...	15 ,, 20	7½
Laundresses	20	...
Cost of living for single men in or about Smyrna, including lodgings, &c.	3 ,, 5	4
Cost of living in the rural districts	3 ,, 4	3½

* Women only work nine hours a day.

Both in and out of town families live relatively much cheaper than individuals.

The labouring classes and their families generally live upon bread, dry and fresh vegetables, fruit, cheese, olives, rice, and occasionally some meat or fish; olive oil is generally used as a substitute for kitchen fat. However, they are rather extravagant in showy dresses, particularly the women.

It will be observed that between the wages earned and the cost of living, a fair balance remains in the hands of the labouring population. These savings are as a rule employed in the first instance in the purchase of a piece of ground, and, next, in the building of a cottage for the family; while free schools for boys and girls, and in case of sickness hospital for indoor and medicine for out-door patients is also provided free by the various communities. Besides, there is hardly a man or woman of the working people but has more or less of a hoard put by for bad times, therefore pauperism is not an indigenous evil.

The population in this country is divided into two classes, viz., the official, mercantile, and land owning form the superior one, while the artisan and general labouring classes form the second. In so far as the town of Smyrna is concerned, provided as they are with a system of free communal schools both elementary and superior, and the natural intelligence of the population, few of the working classes are entirely illiterate, nay, it often happens that children of the artisan class, after finishing their studies in the free Greek gymnasium, go up to the University of Athens, whence they return as physicians or lawyers.

The labouring population in this country are sober, frugal, and thrifty, and generally trustworthy, though inclined to be indolent. In the towns, as stated above they generally possess their own smart cottages, and in the rural districts some land, a few head of cattle, and a cottage.

The feeling between master and servant is good; the latter are treated in a kind and familar way and dealt with liberally; the effect is that employers seldom make large fortunes, nor is there great riches accumulated in a few hands, as is the case elsewhere; nor are the labouring classes ever in absolute want; in fact it may be said the public fortune is distributed between all classes of inhabitants.

There is no organised condition of labour nor capital, and consequently no strikes. The working people are free to purchase necessaries of life whenever they choose. Day labourers are paid every week in the usual current coin of the country.

In conclusion, during the past five years, for both male and female labour, the wages have increased from 10 to 20 per cent.

CORRECTIONS.—Mr. T. Waller desires the following corrections to be made in the report of his remarks in the last number of the *Journal*, p. 397, line 38, *for* 18,000 *read* 1,800; line 41, *for* ten *read* twenty-four.

NOTES ON SILK-PRODUCING BOMBYCES REARED IN 1884.

By Alfred Wailly.

(Continued from page 411.*)*

Attacus Atlas.—Further information is contained in a letter dated October 26th, from my correspondent's wife:—"It is I who rear the silkworms, and consequently am very sorry the cocoons we sent you turned out so bad. I took a great deal of trouble, particularly with the last three boxes. I reared them as they do the *Yama-maï* in Japan, but adopting only two different operations. First on cut branches on zinc spouts filled with water, and after the second and third moulting of the worms, on growing trees covered with netting and tals-screens of split bamboos to prevent red ants and bloodsuckers from devouring the worms. I kept some of the cocoons of each box for breeding purposes, and all the moths emerged at the proper time, and were large and beautiful specimens, and rearing them in this way, I always succeeded in gathering the same number of cocoons as worms. The climate here is admirably suited to both *Mylitta* and *Atlas*, and perhaps to other species too. The sun's heat or any heavy rains do no injury to them. Now, since we have found out that the *Atlas* cocoons can be carded, it is worth rearing them for manufacturing purposes. Of course we think they can be carded because we suceeeded so well in pulling out the whole cocoon with our hands. The silk is so fine and lustrous we think it equal to *Bombyx mori*. The only obstacle to our rearing them on a large scale is that our means are so limited. We have all the experience of twenty years to help us, and nearly three acres of cinnamon bushes planted four feet apart, and cashew and other trees to feed the *Tussur* on too."

Antheræa mylitta.—Early in 1884, I received from Calcutta a case containing large and splendid cocoons of this valuable Indian silkworm; these cocoons, I was told, had been collected in Assam. The moths began to emerge on the 20th of June, and they kept on emerging till the 21st of October. Excepting a few, especially those which emerged in October, when the weather was cold, the moths were in splendid condition. Up to the 15th of August, although I had a number of large and perfect moths, no pairings were obtained. On the 19th of August, I placed a cage, containing a couple of moths, in the garden, and the pairing took place. Another was obtained on the 22nd, a third on the 23rd, and on the 14th of September the fourth and last pairing was obtained. All these pairings took place in the open air. The real cause of the failure in obtaining pairings of this species was then discovered; it was leaving the cages in a room instead of placing them in the open air. Failures with other species were, in all probability, due to the same cause. Cages containing moths should, therefore, always be placed in the open air, unless the weather be too cold. The cages containing the couples were placed in the garden in the evening, and the next morning the moths were found paired, and remained so till late in the evening, the pairings being from twenty to twenty-four hours in duration. It was only when the nights became too cold that no pairings were obtained. From the first pairing 211 eggs were obtained, from the second, 270, and about the same quantity from the third. The season being too far advanced to attempt the rearing of *Mylitta* larvæ without artificial heat, which I had not, I sent most of the eggs to several American correspondents, and some to Spain. I hope at some future time to hear of the result of the experiments from all of them, but as yet, only three have written on the subject, and they have failed in obtaining a satisfactory result, owing to various causes.

Ova sent as far as the State of Georgia arrived in good condition, and the larvæ hatched the day after the box had arrived. But my correspondent, after successfully rearing the larvæ up to a certain point, being obliged to absent himself from home for a fortnight, entrusted them during his absence to a person who, taking no interest in them, neglected them, and my correspondent on his return found them all dead. The eggs sent by me on the 23rd of August arrived in Georgia on the 5th September; they hatched the next morning.

The few eggs I kept of the first pairing, which took place on the 19th of August hatched on the 10th of September; those of the second pairing (22nd of August), hatched on the 13th of September, the hatching of all the eggs having taken place without any artificial heat. It will be seen in my previous article on *C. imperialis*, that Mr. Weniger, of Islington, had *Mylitta* eggs laid on the 28th of August which hatched on the 4th of September, that is seven days' only after they were laid, in his heated glass case. Some eggs of the same brood left in the open air for experiment, hatched on the 28th of September.

Mr. Weniger mentions a fact which, I think, deserves to be recorded. He reared his *Mylitta* larvæ on tender oak leaves till the second stage, then on riper foliage till the end of the 4th stage. After the 4th moult, the larvæ before recommencing to eat had an attack of diarrhœa, and being afraid of losing them, he thought of giving them (after giving them a good washing), by means of a small glass tube some quinine, or rather a decoction of quinquina (Peruvian bark), which they drank with avidity. After the application of this remedy the larvæ recovered, but they still had some difficulty to eat the tough oak leaves. Then remembering that Mr. P. H. Gosse had reared *Mylitta* and also *Atlas* larvæ on hornbeam, Mr. Weniger gave them small branches of the latter, on which they thrived well till they formed their cocoons.

One of my correspondents in Spain, Mr. G. Segin British Vice-Consul, to whom I sent cocoons i

the spring and later on some eggs of *Mylitta*, in a letter dated November 19th, 1884, sends me an account of his experiments in rearing *Mylitta* in Spain.

"Notes on 30 cocoons of *Mylitta* sent from London, and received on the 20th of March, and 3rd of April, 1884, by Mr. Gabriel Segin, in Spain.

"Moths emerged as follows:—On the way from London 1 male emerged, arrived here in bad condition; 3rd June, 1 female; 12th July, 1 male; 15th July, 1 male; 17th July, 1 male, paired with a *Pernyi* female; 20th July, 1 female, deformed; 25th July, 1 female, deformed; 28th July, 2 females, one perfect, the other deformed; 31st July, 1 male, which paired with the good female emerged the 28th; 1st August, 1 male, which fled away from the cage; 2nd August, 1 female, deformed; 6th August, 1 female, good; 7th August, 1 male, this male was kept for several days with the female of the 6th in a cage in a room, and they never paired; 8th August, 1 female, good; 11th August, 2 females, good, one of these paired on the 12th with a male *Pernyi*, very small and feeble; 12rh August, 1 female, good; 13th August, 1 male and 1 female, good; they paired; 14th August, 1 male and one female, which paired; 16th August, 1 male and 1 female, which refused to pair, being kept together in the cage in a room; 23rd August, 1 male and 1 female, never paired, in same condition as the above; 30th August, 1 female, good; 1st September, 1 female; 3rd September, 1 female.

"By the above note you will see that 29 of the 30 cocoons sent, hatched; one cocoon has remained; I fear it is dead. Three pairings of *Mylitta* were obtained from the moths emerged 28th and 31st of July, and on the 13th and 14th August.

"Besides these, one hybrid pairing from male *Mylitta* and female *Pernyi* on the 17th July. Another hybrid from male *Pernyi* and female *Mylitta* on the 11th August. Three couples refused to pair, though they were kept close in cages; the cages were in a room, and probably this circumstance was the cause of their not pairing. Your letter of the 19th September, giving the valuable information that *Mylitta* moths seldom pair in a room, came too late.

"From these pairings 653 eggs were obtained, which began to hatch about 10 days after they were laid; 379 larvæ were obtained, the rest of the eggs did not hatch. The larvæ were reared on oak trees, in the woods, kept in muslin bags, and some others quite free. They seemed to feed splendidly on the oak leaves, and grew very beautifully, and the first spun well their cocoons, 32 in number. On the 29th of September the first cocoon was spun.

"About the 14th or 15th of November, the weather changed suddenly into rainy and cold. A few days before this change we observed that the larvæ which had always been very quietly feeding in their trees (those that were free) began to come down from the trees, and fled away in a hurry. We were obliged to keep them in bags. The most part grew up till the last stage, but languidly, and some died before reaching their full size, but none of them spun their cocoons Our opinion is that the weather was too cold and rainy for the *Mylitta* worms. It was a pity to see those big, enormous worms dying without spinning their cocoons. It seems that the only reason of the accident was that the season was too far advanced, and as soon as the weather changed to winter weather, the rearing of *Mylitta* was impossible. The first worms grew splendidly, and spun well their cocoons; they all fed very well on oak trees."

Hybrid Mylitta-Pernyi.—On the 18th of December, I received the following note from my correspondent in Spain, on this new hybrid silkworm, which is a cross between *Mylitta* male and *Pernyi* female, live cocoons of which I am going to receive:—"The eggs from the pairing of *Mylitta* male and *Pernyi* female were exactly the same as those of *Pernyi*, same size, form, and colour. The larva in its first stage is a little more yellowish in colour, though rather darker, but when full grown it is of a paler green than *Pernyi*, and remarkably more hairy; this was the most conspicuous difference between the hybrid and the pure *Pernyi*. The cocoons resemble those of *Pernyi*, and they proved to be apparently the strongest and best of all cocoons obtained this season. The following note will give an idea of the success obtained with this hybrid:—We obtained from the eggs of the above-mentioned pairing 120 larvæ; these were carefully placed on an oak tree under a muslin bag till their third or fourth stage, then the bag was removed, and we counted 113 worms, that is to say a loss of only seven worms. From these 113 worms, which afterwards grew without any protection, we collected 102 cocoons, all beautiful. This is an extraordinary quantity of cocoons compared with the number of larvæ placed on the tree. It is true that the tree was better protected from rats and birds than the trees where *Pernyi* larvæ were reared. As I said in a previous communication, we could not obtain any cocoon from the hybrid male *Pernyi* and female *Mylitta*. We could only study the larvæ till the third or fourth stage. We found that the eggs were more like those of *Mylitta*, the larvæ also were like those of *Mylitta*, though of a darker colour. They all perished between the third and fourth stage."

Cricula trifenestrata.—In 1882, as may be seen from my report for that year, I received from Madras a large quantity of cocoons of this silkworm, but most of them having hatched during the voyage, it was impossible to attempt the rearing of this species. In 1884, I was much more fortunate, for, with only eighteen out of thirty cocoons which I kept for rearing, I obtained two pairings, and the larvæ were successfully reared by me, and also by several of my correspondents. The moths emerged from the 20th of June to the 5th of July. The first pairing took place on the 29th of June, very early in the morning, shortly after midnight. The number of eggs laid was 221. The second pairing took place on the 7th

of July; 211 eggs being laid. The ova of the first pairing, hatched from the 13th of July, and those of the second pairing, from the 23rd of July. The larvæ were bred in the house, under glasses, with the greatest facility. The larvæ, although (as was the case with the small number I bred) they may form their cocoons singly, or by twos or threes, generally form compound cocoons, which sometimes are of an enormous size. As mentioned in my previous report, the cocoon is a beautiful network of a golden yellow colour. The larvæ of the first brood, which commenced to hatch on the 13th of July, underwent their changes as follows:—Second stage commenced on the 25th of July; third, on the 3rd of August; fourth, on the 10th; and fifth and last stage, on the 16th of August. The larvæ commenced to spin on the 22nd of August, and had all finished spinning within a week's time. The moths from these cocoons all emerged from the 3rd of October to the 12th of the same month, leaving me nothing for the year 1885.

THE RUSSIAN PRESS.

Consul-General Stanton, of St. Petersburg, says that the entire circulation of Russian periodicals does not exceed 2,500,000 copies, and as the population of Russia is estimated at 100,000,000, this leaves one copy for every forty inhabitants. According to official returns, there are 776 periodicals published in Russia, and they appear in 126 towns, 55 per cent. being printed in Government cities, 10 per cent. in small provincial places, and 35 per cent. in the two capitals, St. Petersburg and Moscow. The greatest number—197, or 25 per cent.—are published in St. Petersburg, and after St. Petersburg come Warsaw, with 79; Moscow, with 75; Helsingfors, with 36; Riga, with 23; Tiflis, with 21; Kief, with 20; Odessa, with 19; Kazan and Kartoff, with 11 each; Reval, with 9; Dorpah and Mitau, with 8 each; Meaborg, with 7; four towns with 6, four with 5, twenty-one with 3, thirty-eight with 2, and twenty-seven with each 1 periodical. Of these publications two-thirds are issued in Russian, and one-third in foreign languages, the chief of which are Polish, German, Finnish, and Swedish. In the two Residencies 249 are published in Russian, French, and German, and one in Russian and German. Besides these, 9 are issued in German, 4 in French, 2 in Latin, 2 in Hebrew, and 1 each in English, Polish, Finnish, and Armenian. Of the whole, 92 per cent. are Russian, and 3 in German. The provincial press has a wholly different character; 265, or 52 per cent., are published in Russian; 100 of these are official organs edited by Government, district or church authorities. Of the remainder, 80 are issued in Polish, 43 in Finnish, 39 in Swedish, 36 in German, 13 in Lithuanian, 9 in Armenian, 4 in Grusinian, 2 in French, and 2 in Tartar. More than one-third of the periodicals of Russia, as well in the provinces as in the capitals, are published by various governments, municipal, learned, and other institutions, and, therefore, principally in the Russian language. The responsible editors of the press of the capital, some 272, belong in the main to the bureaucracy. Government institutions edit rather more than 16 per cent., and private, scientific, and municipal institutions 12 per cent. The clergy are represented by six persons, two of whom are Lutherans; and military and civil officials, their wives, widows, and daughters edit 51 per cent. of the periodicals of the capital. Of these persons 36 belong to the upper classes (generals, actual councillors of State, and privy councillors), whilst 65 editors belong to the ordnance department, and the corresponding marine and civil department, and 37 to the higher officials, both military and civil. Professors and artists are estimated at 15 per cent., and in addition to these the two capitals include among their editors 23 noblemen, 3 book dealers, 5 printers, 2 tradesmen, 6 merchants, and 10 foreigners. Of the 504 provincial editors, 180 belong to Government, municipal, scientific, or other associations, 47 to the clergy, 70 to the military and civil services. Of the remaining 272 editors, 42 per cent. have had a university education. The bureaucracy is not so strongly represented as in the residences, only 1 per cent. belonging to the four upper classes of officials. Among the provincial editors are 10 book dealers, 19 printers, 1 artist, 19 noblemen, 14 honorary citizens, and 3 women. Seventy-one per cent. of the periodicals of the capital are published by private enterprise, 11 per cent. at the cost of Government, and 18 per cent. at the cost of various associations. Two hundred and thirty-six periodicals, or 30 per cent. of the whole press, are published without censorship, viz., in St. Petersburg, 101 out of 197; Moscow, 30 out of 75; and in the provinces, 105 out of 504.

Correspondence.

VENTILATION OF PUBLIC SEWERS.

On page 596, Dr. Alfred Carpenter is reported to have said:—"If the soil-pipe of every house were made to act as a ventilator for the sewer, the condition of things would be such that it would be impossible for any large amount of foul air to be discharged, under any circumstances, to the injury of individuals."

Will you permit me to state that I consider that assertion to be a great mistake. Besides, to use our water-closet soil-pipes to ventilate the sewer would

be to open up a highway into our houses for the sewer rats.

The stink of a vertical soil-pipe trapped at its foot, and with fresh air inlet at bottom and open at top, is often bad and dangerous, if it gets into a bedroom especially. If the soil-pipe acts as the ventilator for the house drain, the stink and danger are greater. Then, if the drain and soil-pipe act as a ventilating outlet for the sewer, the stink and danger are greater still, or the worst of the three plans.

Isolation in house drainage—or trapping and ventilating in sections—means safety to the inmates, and is as much needed as—if not even more needed than—isolation in the case of infectious diseases.

There ought to be an interceptor ventilation trap on every drain between the house and the sewer, and all ventilation for the sewer should be on the outer side of this trap.

W. P. BUCHAN.

21, Renfrew-street, Glasgow.
April 20, 1885.

ABOLITION OF WATER CARRIAGE IN THE REMOVAL OF EFFETE ORGANIC MATTER.

In his very valuable and interesting paper, viz., "The abolition of water-carriage in the removal of effete refuse from towns," Dr. Hawksley omitted to refer to two very important features of the question. Firstly, the cost of the requisite appliances to render the water-carriage system as safe as it can be made; and when considered in connection with the dwelling of the working man, it will be seen how utterly hopeless it is to provide this class with a dwelling having any approach even to the standard of safety now admitted necessary by the water-carriage advocates. As the working classes in the receipt of very moderate weekly wages comprise at least four-fifths of the population, this is an important feature. Capitalists have a right to, and do expect a fair amount of interest for their investments in property of this kind.

Secondly, he made no reference to the powerful deodorant already on the premises in the form of fine ash-dust, which has to be disposed of, and when utilised as a deodorant for human soil under my system produces an article of great manurial value, whilst the cinders that have to be removed are sifted ready for re-burning in the premises.

My system has now had years of practical test, and I do not know of an instance where it has failed to give satisfaction. The ash-dust is found to exist in sufficient quantity for its use, but it may be supplemented by dried earth if it is thought desirable.

I cannot suppose that Dr. Hawksley is ignorant of the existence of my ash-screening closet system. He may, however, not know sufficient of it to appreciate it. At my own house, all domestic refuse, excepting bones, tin cans, and broken crockery, is reduced to fine dust, all of which I can use in my own garden, so, as a matter of fact, the dust-cart is never seen at my door; and if Dr. Hawksley cares to learn how this is accomplished, I shall be glad to show him at any time. If Dr. Hawksley will kindly refer to Professor Watts' "Dictionary of Chemistry," he will find the detailed analysis of coal-ash; or if he will refer to Dr. Stockhardts' "Chemistry of Agriculture," he will find that a high value is placed upon sifted coal-ash for sanitary and for agricultural purposes.

J. CONYERS MORRELL.

The Grove, Ealing.

Obituary.

DEAN OF LINCOLN.—The Very Rev. Joseph Williams Blakesley, B.D., died at the Deanery, Lincoln, on Saturday morning, 18th inst. He was born in London in 1808, educated at St. Paul's School and at Trinity College, Cambridge, where he graduated in 1831, as 21st Wrangler and Senior Chancellor's Medallist. Mr. Blakesley was vicar of Ware, Herts, from 1845 till 1872, when he was nominated to the Deanery of Lincoln. He was the author of several works, and a member of the Society of Arts since 1879.

General Notes.

THE MOON'S ORBIT.—The model of the moon's orbit will remain on exhibition all next week, together with a working model, illustrating "axial parallelism as a fundamental principle in the construction of the solar system." And also a model illustrating the simple relation of the circle to the straight line—all arranged by Mr. John Harris.

MEETINGS OF THE SOCIETY.

APRIL 29.—"Researches on Silk Fibre." By THOMAS WARDLE.

MAY 6.—"Nobert's Ruling Machine." By J. MAYALL, jun.

MAY 13.—"A Marine Laboratory as a Means of Improving Sea Fisheries." By Professor E. RAY LANKESTER, M.A., F.R.S. E. L. BECKWITH, Prime Warden of the Fishmongers' Company, will preside.

MAY 20.—"The American Oil and Gas-fields." By Professor JAMES DEWAR, F.R.S.

Indian Section.

Friday evenings at Eight o'clock.

May 1.—"Herat." By Professor Vambery.

[Admission to this meeting will be by tickets only.]

May 8.—"The Ancient and Modern Methods of Treating Epidemics of Small-pox in India." By Robert Pringle, late Sanitary Department H.M. Bengal Army. Sir Philip Cunliffe-Owen, K.C.M.G., C.B., C.I.E., will preside.

May 15.—"The Golden Road to South-Western China." By R. K. Douglas, Professor of Chinese at King's College, London. The Hon Edward Stanhope, M.P., will preside.

Foreign and Colonial Section.

Tuesday evenings at Eight o'clock.

April 28.—"The Federation of the Empire." By J. E. Gorst, M.P. The Right Hon. W. E. Forster, M.P., will preside.

May 19.—"New Britain and the Adjacent Islands." By Wilfred Powell. Sir Francis Dillon Bell, K.C.M.G., will preside.

Cantor Lectures.

Monday Evenings at Eight o'clock.

The Sixth Course, "Photography and the Spectroscope." By Captain C. W. de W. Abney, R.E., F.R.S.

Lecture II. April 27.—The diffraction spectrum. The ordinary grating. Influence of the number of lines on resolving power. The reflection grating. The flat reflection grating. Absorption of radiation and atomic motion, and the formation of the photographic image.

The Seventh and concluding Course, "The Manufacture of Toilet Soaps." By C. R. Alder Wright, D.Sc., F.R.S., F.C.S.

May 4, 11, and 18.

Admission to Meetings.

Members have the right of attending all the Society's meetings and lectures. Every member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the members, but admission can also be obtained on the personal introduction of a member.

MEETINGS FOR THE ENSUING WEEK.

Monday, April 27...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Captain C. W. De W. Abney, "Photography and the Spectroscope." (Lecture II.)

Geographical, University of London, Burlington-gardens, S.W, 8½ p.m. 1. Mr. Everard im Thurn, Letter announcing the Ascent of Mount Roraima, British Guiana. 2. Mr. H. J. Perkins, "Notes on the Journey to Roraima and Ascent of the Mountain."

Actuaries, The Quadrangle, King's College, W.C., 7 p.m.

Inventors' Institute, Lonsdale-chambers, Chancery-lane, W.C., 8 p.m. Mr. W Wilkinson, "Worm-geared Locomotives for Tramways."

Medical, 11, Chandos-street, W., 8½ p.m.

Tuesday, April 28..SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Mr. J. E. Gorst, "The Federation of the Empire."

Royal Institution, Albemarle-street, W., 8 p.m. Professor Gamgee, "Digestion and Nutrition." (Lecture VII.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 3½ p.m. Special General Meeting of Corporate Members only, to decide upon proposed alterations in the Bye-laws. 8 p.m. Professor H. S. Hele Shaw, "Mechanical Integrators."

Wednesday, April 29...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Thomas Wardle, "Researches on Silk Fibre."

Geological, Burlington-house, W., 8 p.m. 1. Prof. P. Martin Duncan, "The Structure of the Ambulacra of some Fossil Genera and Species of Regular Echinoidea." 2. Dr. H. J. Johnston-Lavis, "The Physical Conditions involved in the Injection, Extrusion, and Cooling of Igneous Matter." 3. Dr. R. von Lendenfeld, "The Glacial Period in Australia."

United Service Institution, Whitehall-yard, 3 p.m., Captain C. C. Fitzgerald, "How can we make the most of our Ships."

Thursday, April 30...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Mrs. Sheil, "Physiology and the Laws of Health." (Lecture IX.) "Digestion and Nutrition."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. W. Cave Thomas, "The New Æsthetics."

Royal Institution, Albemarle-street, W., 8 p.m. Prof. Tyndall, "Natural Sources and Energies." (Lecture III.)

Mechanical Engineers, 25, Great George-street, S W., 3½ p.m. 1. Mr. Hiram Maxim, "Description of the Maxim Automatic Machine Gun." 2. Prof. Alexander B. W. Kennedy, "Abstract of Results of Experiments on Rivetted Joints, with their Applications to Practical Work." 3. M. Louis Poillon, "Description of the Tripier Spherical Eccentric." 4. Mr. Calvert B. Holland, "Description of a Blooming Mill with a Balanced Top Roll at the Ebbw Vale Works."

Friday, May 1 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Prof. A. Vambéry, "Herat."

Royal Institution, Albemarle street, W., 1½ p.m. Annual Meeting. 9 p.m. Lord Rayleigh, "Water Jets and Water Drops."

Mechanical Engineers, 25, Great George-street, S.W., 7½ p.m. Reading of Papers and Discussion continued.

Geologists' Association, University College, W.C., 8 p m.

Philological, University College, W.C., 8 p.m. Mr. A. J. Ellis, "Report on Dialectal Works."

Saturday, May 2..Royal Institution, Albemarle-street, W., 3 p.m. Mr. W. Carruthers, "Fir Trees and their Allies." (Lecture II.)

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FRIDAY, MAY 1, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

INTERNATIONAL INVENTIONS EXHIBITION SEASON TICKETS.

The Executive Council of the International Inventions Exhibition have consented to allow Members of the Society of Arts the privilege of purchasing Season Tickets for the Exhibition at half-price (10s. 6d.) Any member desiring to avail himself of the privilege can obtain a ticket by applying to the Secretary, and remitting the price, 10s. 6d. Each member will only be allowed the privilege of purchasing a single ticket on these terms, which will be a personal admission, not transferable. It will be understood that all applications must be accompanied by the above-named remittance, and that tickets at the reduced rate can only be obtained from the Secretary of the Society.

Season tickets admit to the opening ceremony on Monday, 4th May.*

CANTOR LECTURES.

The second and concluding lecture of the sixth course on "Photography and the Spectroscope" was delivered by Captain C. W. de W. Abney, R.E., F.R.S., on Monday evening, 27th inst.

A vote of thanks to the lecturer was passed on the motion of the Chairman.

The lectures will be published in the *Journal* during the summer recess.

* For details of the arrangements see p. 687.

Proceedings of the Society.

HOWARD LECTURES.

ON THE CONVERSION OF HEAT INTO USEFUL WORK.

By William Anderson, M.Inst.C.E.

Lecture IV.—Delivered December 19, 1884.

In my last lecture, I explained the great principle first laid down by Sadi Carnot in 1824, that in a heat engine the effect depends solely and entirely upon the fall of temperature caused by the external work done by the working substance, and not in any way on the nature of the substance, its absolute temperature, or on the mode in which it was heated or cooled. We know by experience that if we desire to heat a body, we must bring it into relations with some body hotter than itself, and then the more energetic molecular motion of the hotter body will gradually be transferred to the colder one, until an equality is attained.

Now, what is true of the transfer of invisible molecular motion from one body to another, is equally true of the transfer of the invisible molecular motion of heat, and its change into the coarser and apparent motion of mechanical work. If an insulated hot body is doing external work, its temperature must fall, just as the swing of the single ball in the ball frame which I have exhibited here is reduced by transfer of its energy to the other balls.

The law of Carnot is, therefore, universal, that where a hot body does external work, a corresponding quantity of heat disappears as heat, and the amount of work done is in proportion to the fall of temperature, because the quantity of heat contained by the working substance varies as the temperature.

The laws of Carnot, as stated by himself, are the following:—

1. The motive power of Heat is independent of the agents employed to develop it, and its quantity is determined solely by the temperatures of the bodies between which the final transfer of caloric takes place.

2. The temperature of the agent must, in the first instance, be raised to the highest degree possible, in order to obtain a great fall of caloric, and, as a consequence, a large production of motive power.

3. For the same reason, the cooling of the agent must be carried to as low a degree as possible.

4. Matters must be so arranged that the passage of the elastic agent from the higher to the lower temperature must be due to an increase of volume, that is to say, the cooling of the agent must be caused by its rarefaction.

The last part of the fourth law should read "the cooling of the agent must be caused by the external work it performs." Carnot was ignorant of the cause of the fall of temperature of gases expanding and doing work, and he held the emission theory of heat. Our admiration for the clearness of his views is greatly heightened by the consideration of the limited knowledge available in his time.

The sources of heat on the surface of the earth are numerous, and, in their application, they give out the heat potential in them in various forms, such as heat, light, electricity, mechanical and molecular motion, chemical effect; and all these have an exact mechanical equivalent. Conversely, mechanical power may be transformed into other forms of energy.

The gas burning in this room owes its brilliancy to the heat engendered by the clashing together, in chemical union, of the constituent atoms of the gas and of the oxygen of the atmosphere. The burners not only radiate light, but also heat; they are causing currents in the air of the room, and most of them are sending sound pulses more or less loud in all directions. I hold this thermopile next this jet; the galvanometer instantly indicates that a current of electricity has been set up; the energy represented by light and radiant heat has been converted into a galvanic current.

This glass rod, which I have already brought under your notice, will illustrate the converse principle. I rub it energetically, you hear a musical sound; the power of my arm has set the rod into longitudinal vibration, as you see by the vigour with which the little glass ball bounds from its end; that vibration has communicated musical pulses to the air. In addition, the rod has become hot, as you see by the indications of the thermopile, which has transformed a portion of the heat-energy into an electric current, competent to deflect the needle of the galvanometer; and, in addition, the gold-leaf electroscope shows that frictional electricity has been developed. This experiment demonstrates how wide is the field in which we must search in order to collect all the reactions corresponding to any particular mechanical effort. The debtor side of the account is generally composed of only one item, but the creditor side is made up of expenditure in many directions, and in that respect bears a strong resemblance to the same side in ordinary financial transactions.

The ultimate source of all energy is the sun. I cannot stop to discuss the various theories as to whence the solar heat originally came, and how the enormous waste continually going on is made good. I must content myself with stating that the compound rays emitted by the sun warm the earth, producing vast movements of water, in consequence of evaporation and the formation of clouds, and so we have warmth and moisture, upon which the growth of the vegetable and animal kingdom depends. Vegetation, as you are probably aware, derives most of its food not from the earth, into which its roots penetrate, but from the air. The lovely mantle of green leaves, which adorns the productive portions of our planet, is not intended to beautify alone: the vast surface exposed to the air has the property, under the influence of the actinic or chemical rays of the sun, of decomposing the carbonic acid in the atmosphere, of assimilating the carbon, converting it into the ligneous part of plants, and rejecting the oxygen, which is, however, essential to the life of animals, by whom it is inhaled, and, again rejected, restored to the condition of carbonic acid.

The quantity of carbonic acid in the atmosphere is relatively small, varying from three parts by measure to ten parts in 10,000, but, absolutely, the weight of carbon thus diffused is greater than all the carbon in the solid form on the face of the earth.

The sources of carbonic acid are the expirations of animals, the combustion of vegetable and animal substances, and emanations of a volcanic character. Wood contains from 46 to 55 per cent. of carbon, all derived from the atmosphere; and because the quantity of carbonic acid there is so small, an immense leaf surface is necessary to collect sufficient for the growth of the plant. By long continued contact with moisture and warm air, wood slowly decomposes by combining with oxygen, and is converted, according to circumstances, into vegetable mould, peat, lignite, or, finally, into coal, which, in the form of anthracite, consists of almost pure carbon.

The work done by the sun's rays in decomposing the carbonic acid of the air is very great. The energy which must be exerted to

separate the carbon from its oxygen is the same as that developed by the combination of the same elements in combustion, and has been determined, by experiment, to be equal to 14,544 units of heat per pound of carbon consumed. By an easy calculation, it can be deduced that every ton of carbon separated from the atmosphere in twelve hours involves energy represented by 1,058 horse-power expended by the sun; but as this energy operates over an enormous leaf surface, its effects are quite imperceptible to our senses.

The mechanical view to take of fuels is, that their component elements are in a state of potential energy with respect to the oxygen of the air, or, as in the case of explosives, with respect to each other. This energy has a strictly definite value for each kind of fuel, just like the potential energy of a body of water is a perfectly definite quantity with respect to its available fall.

The precise amount of this energy has been determined by many experimentalists, and especially by Favre and Silbermann, who, between the years 1845 and 1852, carried out an admirable series of experiments, the substantial accuracy of which has been confirmed by subsequent investigations.

Their method of experiment was to carry on the combustion of various substances in oxygen and other gases in a small chamber surrounded by water, and fenced about with elaborate precautions against loss of heat by conduction or radiation. The water was kept agitated, and, by the increase of its temperature, the number of units of heat due to combustion was calculated.

The table on page 646 gives the calorific value of different substances which enter into the composition of ordinary fuels.

The general conclusions arrived at by Favre and Silbermann, Berthelot, and others, are that, as a rule, there is an equality between the heat disengaged or absorbed in the acts respectively of chemical combination or de composition of the same elements, so that the heat evolved during the combination of two simple or compound substances is equal to the heat absorbed at the time of their chemical segregation, and the quantity of heat evolved is the measure of the sum of the chemical and physical work accomplished in the reaction.

The theories we have been discussing would naturally lead to the latter conclusion. The molecular energy set up by the conversion of the potential energy of the fuel into the kinetic form would most probably be expended in part, in the case of compound bodies, in the work of breaking up their structure before fresh combinations could take place, and, on the other hand, we can conceive chemical combinations of a nature that, on breaking up, would yield heat. Thus, carbon burned in protoxide of nitrogen, or laughing gas, N_2O, produces about 38 per cent. more heat than the same substance burned in oxygen; whereas in marsh gas, or methane, CH_4, the energy of combustion is considerably less than that due to the burning of the carbon and hydrogen separately.

Nearly all fuels consist of carbon, hydrogen, and oxygen. It is convenient to reduce the hydrogen to its heat equivalent of carbon. The table tells us that hydrogen developes 62,032 units per pound, while carbon developes only 14,544, so that hydrogen gives out 4·265 times more heat than carbon, and may be thus represented by it, $H = 4·265\ C$.

I have already remarked that, in dealing with gases near their points of liquefaction, great circumspection must be used. The case of the combustion of hydrogen offers an excellent illustration. Favre and Silbermann condensed the products of combustion, and so determined the total quantity of heat developed, which included the latent heat of evaporation; but in furnaces, the water formed in the combustion of hydro-carbon fuels passes off in the state of vapour, hence the latent heat of evaporation is not available. One pound of hydrogen burns to 9 lbs of water, the latent heat, at 212°, is 966 units, hence we must deduct $966 \times 9 = 8,694$ units from the tabular value of the heat due to the combustion of hydrogen, which leaves only 53,338 units available; therefore, the value in terms of carbon is $H = \frac{53338}{14544} C = 3·67\ C$, or 14 per cent. less than if the vapour formed were condensed to water. I am indebted to Mr. Deering, of the Chemical Department of the Royal Laboratory at Woolwich, for pointing out to me this important correction, which appears to have escaped the acuteness of even so careful and profound a writer as the late Professor Rankine.

The oxygen in fuel exists, for the most part, united to hydrogen in the form of water, and is, therefore, already in chemical union with a portion of the hydrogen, and incapable of further work; hence the equivalent weight, or one-eighth of the oxygen, should be deducted from the hydrogen before it is reduced to its equivalent value of carbon. The calculation

PROPERTIES OF FUELS.

		Composition by weight.						Units of heat per lb.	Pounds water evaporated from and at 212°.	Pounds dry air to one pound of fuel.	Calculated rise of temperature due to combustion.	Units of heat per pound of complete fuel.
		Carbon.	Hydrogen.	Nitrogen.	Oxygen.	Sulphur.	Ash.					
	Atomic weight	12	1	14	16	32						
1	Durham coke	93.78	...	...	...	·82	5·4	13,640	14·12	10·91	4,877°	1,145
2	Anthracite	90·39	3·28	·83	2·98	·91	1·61	14,698	15·21	11·53	4,856°	1,173
3	Newport steam coal	81·47	4·97	1·63	5·32	1·10	5·51	14,143	14·64	10·99	4,830°	1,180
4	Wigan cannel coal	80·07	5·52	2·12	8·09	1·50	2·70	14,051	14·55	10·92	4,800°	1,179
5	Wolverhampton ten-yard seam	78·57	5·29	1·84	12·88	·39	1·03	13,390	13·86	10·41	4,765°	1,174
6	Petroleum	85·	15·	...	...	..	...	20,363	21·08	15·07	4,900°	1,267
7	Oak wood (dried at 284°)	49·95	6·	1·13	41·27	...	1·65	7,713	7·98	6·08	4,287°	1,089
8	Illuminating gas, by weight	61·26	25·55	8·72	4·47	...	...	20,801	21·53	15·66	4,567°	1,249
9	Do. do. per 1,000 cubic feet, at 30" pressure, 60° Fahr. = 29·685 lb.	lbs. 18·19	lbs. 7·58	lbs. 2·59	lbs. 1·33	...	...	Per 1,000 cubic ft. 617,485	639	465	...	...
10	Gunpowder	Charcoal. 14·2	Water. 1·	Nitre. 74·7	...	10·1	...	1,300	...	None.	3,960°	1,300

NOTES TO THE TABLE OF FUELS.

By W. H. Deering.

Column 2.—Units of heat per 1 lb. consumed.—The numbers given under this column are calculated with values for the heat of combustion of hydrogen, of marsh gas, and of ethylene, which assume that the water produced by their combustion remains in the gaseous state; an assumption rendered necessary for the requirements of column 3, where the products of combustion are to heat water already at 212° Fahr.

The heat of combustion of carbon is taken as 14,544 lb.-degrees (Fahrenheit), that of hydrogen as 53,339 lb.-degrees, and the hydrogen available as fuel is supposed to be given by:—Total hydrogen—⅛ oxygen.

No allowance is made in the calculation of the coals for evolution of heat in the burning of the small quantity of sulphur, there not being adequate data.

The heat of formation of the different coals not being certainly known, these calculated numbers for heat of combustion will be useful for comparison, but must not be taken as the quantities that would actually be obtained.

In the case of illuminating gas (No. 8), which is taken as dry, the total heat of combustion, given under column 2, is calculated from the constituents: hydrogen, marsh gas, carbonic oxide, &c., using the respective experimentally obtained values.

In the case of petroleum, the numbers given for the calorific power of petroleums No. 6 A and 6 B are corrected experimental numbers, obtained by Deville, who worked on a large scale.

The correction of Deville's experimental number for calorific power consists in the deduction of the latent heat of the water, produced by the combustion of the petroleum; he having cooled his chimney gases, and liquefied the water.

The calculated number for 6 B is about 1,500 units, or about 1-12th higher than the experimental; partly to be accounted for by the heat of formation of the petroleum being a positive quantity.

Deville also determined the calorific power of Baku petroleum, and found it to be somewhat higher than that of Pennsylvanian petroleum. The experimental number was 700 Fahrenheit units (or 1-26th) lower than the number obtained by calculation from the per-centage composition of the petroleum.

Column 4.—Weight of dry air required for combustion.—An allowance is made for the air required for the combustion of the sulphur contained in the coal and coke. It is regarded as half being in combination in the non-mineral part of the coal, and half being present as iron pyrites. The sulphur is supposed to be burnt to SO_2, and the iron to ferric oxide, when on the above suppositions 1lb. sulphur requires 4·89lbs. of air. It does not much matter if the fundamental suppositions are not wholly correct, as 1 per cent. of sulphur so calculated requires only 0·05lb. of air, when 1lb. of coal is burnt.

Column 5.—Maximum Rise of Temperature.—The specific heats of the products of combustion: carbon dioxide, gaseous water, and of the nitrogen of the air, used in the calculation of maximum rise of temperature are 0·217, 0·48, 0·244 respectively; and are the specific heats of those gases at constant pressure.

The numbers given under this column have some value for the purpose of comparison, but must not be taken as temperatures actually attainable. First, because dissociation of the elements of CO_2 and H_2O would take place at temperatures much below those given; the consequence of which would be that, at the hottest place of combustion, there would be some unburnt, and there unburnable, carbonic oxide and hydrogen.

Secondly, because the specific heats of gaseous water, of carbon dioxide and of nitrogen, are probably higher at the maximum temperatures of the combustion of the different fuels, than the values used for the calculation of column 5. The rise with temperature of the specific heat of carbon dioxide has long been known to be very considerable even a low temperatures, and recent researches of Berthelot and Vieille render it more than probable that there is also a great rise in the specific heats of gaseous water and of nitrogen at high temperatures. The use of these higher values for the specific heat of the gases mentioned would, of course, lower the calculated maximum rise of temperature.

takes this form when the water passes away in the state of vapour—

$$\text{Heat of combustion} = 14544 \left\{ C + 3{\cdot}67 \left(H - \frac{O}{8}\right) \right\}$$

The formula does not always apply exactly, as, for example, in the case of marsh gas, where the heat developed is less than that due to the separate combustion of the carbon and hydrogen, namely, 23,513 units only, against 26,416, the theoretical amount.

The case of gunpowder is peculiar in every way. The chemical reaction which takes place is not very well understood. Powder contains all the ingredients of combustion in itself, and is not dependent on the oxygen of the air. The conversion into gas is very imperfect, only 43 per cent. becoming gaseous, while 57 per cent. is shattered into a very finely divided state, ultimately forming the smoke which characterises the explosion of powder.

In comparing the calorific value of fuels, it is desirable to associate with them the air necessary for their combustion, because, by doing so, self-contained combustibles, such as explosives, can be brought into the category. When the chemical composition of any fuel is known, it is easy to calculate the quantity of oxygen required to ensure complete combustion, and remembering that this gas constitutes about 22 per cent. of the weight of the atmosphere, the weight of air is easily arrived at. In the table on page 646 is given the chemical composition of different kinds of fuel, the units of heat derived from the complete combustion of a pound of each, the corresponding weight of water evaporated from and at 212°, and the weight of air required for combustion.

You will observe that gunpowder stands apparently in a very unfavourable position, yielding only 1,300 units against nearly 15,000 for some kinds of coal, but the comparison is not fair, because the other kinds of fuel are in an imperfect state. To make them self-contained, like gunpowder, we should add to each the weight of air necessary for its combustion, and then we get a singular uniformity in the units of heat per pound of complete fuel, as you will see by inspecting the last column in the table; and as in gunpowder there is no less than 57 per cent. of inert matter, so in the complete fuels no less than 72 per cent. is inert under the most favourable circumstances.

I have already given you Berthelot's first law of thermo-chemistry. I will now add two others.

2. When a system of bodies, simple or compound, starting from a given condition, undergoes chemical changes which bring it into a new condition without producing any mechanical effect on external bodies, the amount of heat evolved or absorbed as the total result of these changes depends solely on the initial and final states of the system, and is the same whatever may be the nature or order of the intermediate states.

An illustration of the application of this law occurs in the combustion of carbon when in thick layers.

The fuel near the bars is completely oxydised, and passes into the mass of glowing carbon above it in the form of carbonic acid gas, composed of one equivalent of carbon united to two equivalents of oxygen. In the mass of heated fuel the carbonic acid yields up one equivalent of oxygen to the carbon, and reaches the surface of the fire in the form of carbonic oxide, and here, meeting with a supply of air, the oxide burns, with a pale blue flame, to carbonic acid again. Berthelot's second law tells us that the intermediate reaction in the mass of glowing fuel does not affect the final result as far as the development of heat is concerned, so that, for the purpose of estimating the thermal value of fuel, all we require to know is its original composition and the final chemical nature of the products of combustion.

Berthelot's third law states, "that in any chemical reaction between a system of bodies, not acted on by external forces, the tendency is towards that condition, and towards those products, which will result in the greatest evolution of heat."

This law, therefore, furnishes a guide when calculating the heating power of fuels of complex structure, and which may oxidise into various substances, as to which combination is most likely to take place, for it tells us that we must select those reactions which will yield the most heat.

The table I have presented to you is calculated in accordance with the above laws. The heat equivalents of the elementary bodies, of marsh gas and olefiant gas, have been arrived at by direct experiment. The effects due to the explosion of gunpowder have been derived from the splendid and truly practical experiments of Sir Frederick Abel and Captain Noble. Mr. Deering has very kindly revised my calculations, and made some important corrections, based upon the most recent information we possess respecting the chemistry of fuels.

As it is my especial object to apply the doctrine of Carnot to the conversion of heat

into useful work, it is necessary now to determine the highest temperature which can be obtained by chemical reaction.

It is much to be deplored that we have not, as yet, a trustworthy pyrometer capable of indicating temperatures above the melting point of platinum, we are therefore reduced to the necessity of being content with calculations. In these calculations, there are several elements of uncertainty.

First, as to whether combustion is complete; secondly, as to the quantity of air entering the furnace; thirdly, as to whether the specific heats of the gases are not subject to variation at very high temperatures; and, lastly, the part played by dissociation. There is a certain temperature below which the energetic chemical reaction, which we call combustion, cannot take place. Thus, coal-gas cannot be ignited below red heat, say 1,000°, and carbon requires a much higher temperature. Anything in the arrangement of a furnace which tends to cool the fuel below the temperature of combustion will lead to imperfect action. Sir Humphry Davy availed himself of this fact in constructing his safety lamp.

Explosive gases, though they freely pass through the meshes of wire gauze, are so cooled by contact with the comparatively cold metal, that though they may be burning on one side of the gauze, the combustion ceases as the gases pass through.

I have here a small coal gas flame, over which I hold pieces of $\frac{1}{2}$ inch gas pipe of various lengths. You see that the flame passes through the shortest piece, while the longer one extinguishes it. The reason is that in the former case the surface of the tube was not sufficient to abstract the heat from the flaming gas, so as to lower the temperature below that of combustion, while in the latter case it was. That the nature of the gas has not been altered in any way, is proved by the circumstance that it can be lighted as you see, on issuing from the top of the tube.

In the construction of furnaces, the facts above stated must not be lost sight of. So long as chemical reaction is taking place, all that tends to cool any portion of the gas should be avoided.

Mr. Frederick Siemens has carried this principle into practice with great success in the regenerative gas furnace. It was formerly considered that the smaller the furnace, and the closer the flame approached the objects to be heated, the better the result, but Mr. Siemens has boldly deviated from this doctrine. He has greatly enlarged the volume of the furnace. He introduces the gas and air at a moderate distance from the sides, bottom, and top, and increases the span of the flame so as to insure complete combustion before the opposite side of the hearth is reached. The flame thus forms an isolated body, acting by radiation from the brilliantly incandescent particles of carbon alone, and the practical result attained is,—a higher temperature, due to complete combustion;—an increased durability of the furnace, due to the circumstance that the firebrick is not exposed to the erosion caused by the friction of the highly heated gases;—and, lastly, less deleterious effect upon the substances being heated. The same principle he has applied to boiler furnaces. By placing rings of firebricks at intervals in the flues, he keeps the flame from contact with the boiler plates. It parts with its heat by radiation alone, until the chemical reaction is complete, and then the heat may be abstracted from the products of combustion by contact, either in passing through small tubes or in any other way. I have here a model of a horizontal flue constructed in mica, which Mr. Siemens has kindly lent me. Rings of brass serve to confine the body of flame which you see passing along the tube, but kept completely from contact with it.

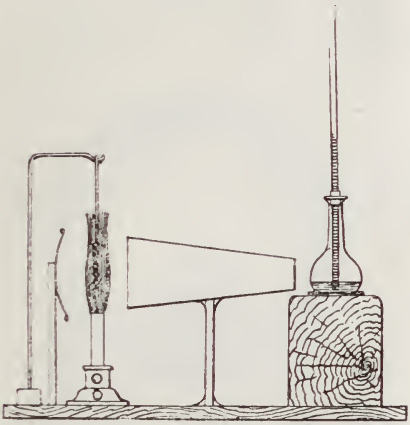
Mr. Siemens' method of heating furnaces by radiation is specially applicable when the flame is luminous, that is to say, charged with white-hot particles of carbon. A pale non-luminous flame, such as you see in a Bunsen burner, has very little radiating power, because air, nitrogen, and carbonic acid, which form the bulk of such flame, are very bad radiators of heat. The vapour of water is a good radiator, but it forms a very small portion of the products of combustion. Solid carbon, on the other hand, is an excellent radiator and absorber, and on that account a mass of flame charged with it will radiate heat powerfully. I have here a Bunsen burner, (Fig. 22, p. 649), arranged so that the radiation from the flame can be concentrated by a concave mirror and cone on the blackened bulb of a large air thermometer. This luminous and comparatively cold flame has been burning since the commencement of the lecture, and the thermometer has now attained its maximum height. I admit air, and convert the flame into an intensely hot but non-luminous one. You see that the thermometer rises very little, but if I hang a spiral of wire in the flame, it begins to

glow and to radiate its intense heat powerfully, causing the thermometer to rise rapidly.

Smoke in furnaces is not altogether an evil, because it serves the purpose of the spiral wire; it improves the radiating powers of the hot products of combustion.

In an ordinary furnace the fuel is in the most disadvantageous condition for complete combustion. It lies in large lumps loosely on the grate, with large and irregular interstices, through which the air and gases evolved have to make their way. In many places the streams of air are so thick that they do not come intimately into contact with the fuel at all, and pass through nearly unchanged, hence, as a rule, a large excess of air, amounting generally to 50 per cent., has to be admitted. In addition, the combustible

Fig. 22.

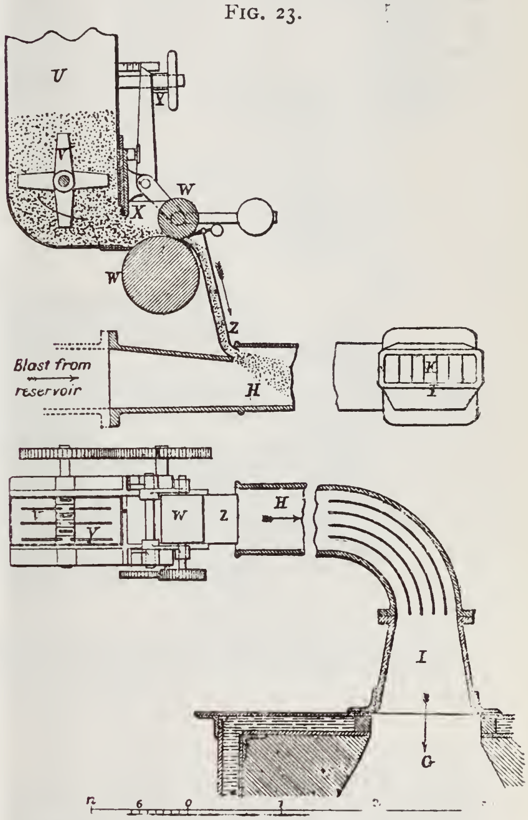


Bunsen Burner.

gases evolved are, in places, cooled below their points of combination by contact with large masses of air, and hence free carbonic oxide and particles of unconsumed carbon are generally found associated with the products escaping by the chimney.

By mechanically subdividing the fuel, and mixing it intimately with only the proper weight of air, the completeness and intensity of combustion may be greatly enhanced. Such a disposition we have in Mr. Crampton's dust-fuel furnace. The fuel is reduced to the finest possible state of subdivision—so fine as to pass through a sieve of 100 meshes to the inch—by means of a disintegrator or a pair of mill-stones; it is then conveyed into a hopper, furnished with agitators, which force it through an opening, the width of which can be regulated at pleasure, into a pair of rollers, which feed the fuel at a uniform rate into a slit in a pipe, along which a blast of air is passing. The dust mixes intimately with the air, and is carried along by it into the furnace, where it at once flashes into flame, of a temperature so intense that wrought iron can be easily melted. Simple as the process is, it has taken the inventor many years to overcome the minor difficulties which surrounded the practical application. One of these consisted in turning corners with the blast-pipe. The particles of coal, in obedience to the first law

Fig. 23.

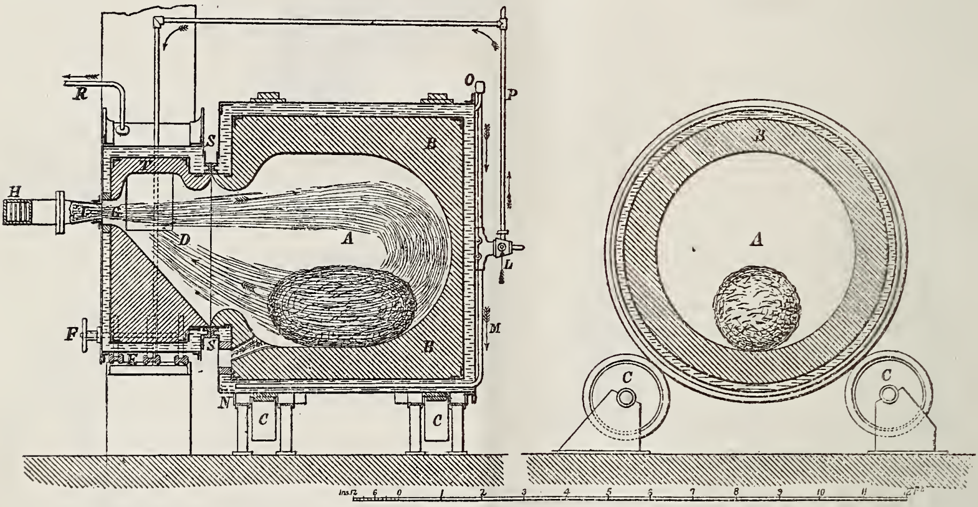


Crampton's Dust-fuel Feeding Apparatus.

of motion, tended to maintain a rectilinear course, and could only be turned from it by the bent sides of the pipe; the consequence was that where a bend occurred, the coal-dust separated from the air, and collected along the concave side of the pipe. By introducing a number of parallel curved partitions into the bend, this action was, in a great measure, neutralised. Another difficulty lay in the erosive action of the particles of solid fuel on the brick lining of the furnace, but this has been overcome by the use of water-jackets, and by the proper direction given to the flame. By the kindness of

Mr. Crampton, I am enabled to bring before you diagrams of his revolving puddling furnace heated by dust fuel, and the same system adapted to marine boilers, with which some extensive experiments were made at Sheerness by the Admiralty in 1872—73, with satisfactory results. It is obvious that the proportion of air and fuel, and the rate at which both are supplied, can be accurately adjusted, and, as a matter of fact, Mr. Crampton finds that he can use the theoretical proportion of air required by the coal, and at the same time secure complete combustion and total absence of smoke. The consequence is, that the chemical action is so energetic that a very high temperature is reached at once with cold air and cold fuel. The manual labour connected with the system is really confined to supervision; it would seem therefore peculiarly fitted for steam ships, where stokers are exposed to so much hardship, especially in tropical climates, and where their cost is a serious item in the expenses of a voyage. The tonnage necessary for the accommodation of stokers, and the stores required by them, would probably exceed the space which grinding machinery would occupy. It is much to be regretted that the distinguished engineer, who is the author of a process scientifically correct and eminently practicable, should not devote himself to its more extended introduction, especially as all the difficulties connected with the system appear to have been completely overcome. In the case of liquid fuels.

FIG. 24.



CRAMPTON'S DUST-FUEL FURNACE.

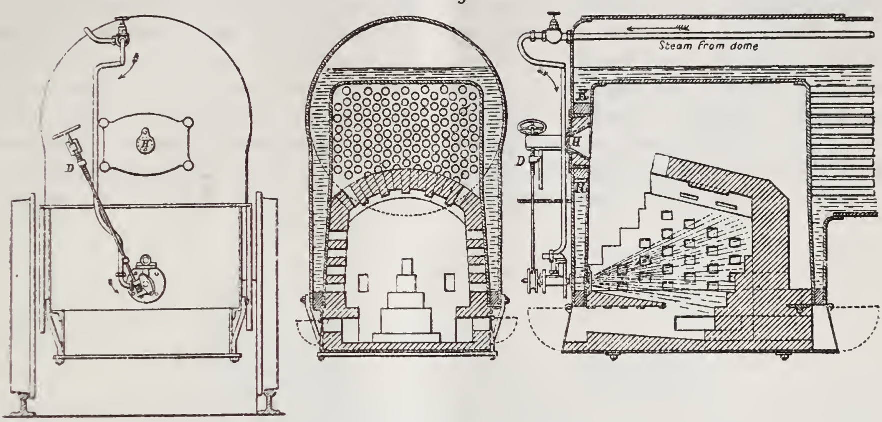
such as petroleum, a similar intimate mixture with the air can be attained, and the relative quantity of each regulated. The apparatus now invariably used is some form of injector, by means of which, through the agency of a jet of steam or compressed air, the fuel and air are introduced into the furnace. One of the most successful applications to locomotives is that made by Mr. Urquhart, the engineer of the Grazi and Tsaritsin railway, in South-eastern Russia. The Figs. 25 and 26 (p. 651) illustrate his method. The injector is of the ordinary circular type, impelling a solid jet of steam and petroleum, surrounded by a current of air, through a tube traversing the water space at the bottom of the firebox. To keep up the temperature of the flame, during combustion, the oil is thrown into a brick oven, built upon the ash-pan, and from thence it is distributed, by numerous openings, into the firebox, where the chemical reaction is completed, and the heat afterwards absorbed by the boiler tubes. On the Volga, and the Caspian Sea, petroleum refuse has now almost superseded all other fuel in marine boilers. One of the forms of apparatus in use is illustrated in Fig. 27 (p. 652).

The injector, in this case, delivers a hollow cone of oil. Air is introduced both inside and outside the jet, so that the mixture is still more intimate than in the arrangement adopted by Mr. Urquhart. The furnaces are not always lined with firebricks, but from what I have already said, it is obvious that a lining would tend very much to promote complete combus-

tion, and would, at the same time, protect the boiler plates from the intense heat engendered in the immediate vicinity of the flame as it is first formed.

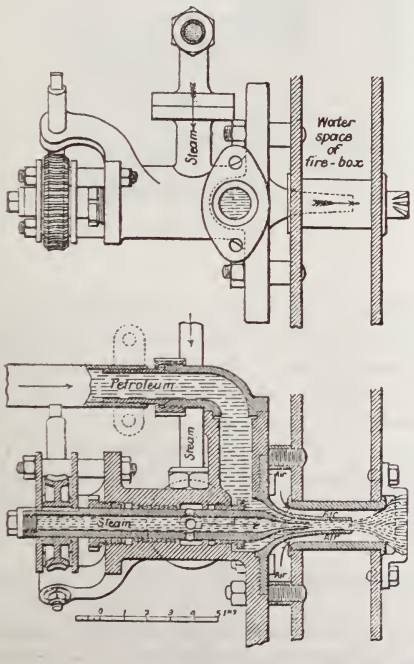
A still finer subdivision of particles is attained when the fuel is made to assume the gaseous form before combustion sets in. We have a splendid illustration of this method in the Siemens regenerative gas furnace. According to this system, a crude gas is manufactured in a species of oven called a "producer" (Fig. 28, p. 653). The oven is of peculiar shape, and is fitted with a fire grate at the bottom. A considerable depth of fuel is kept

FIG. 25.



on the bars. The layer, in immediate contact with the air entering between the bars, burns to carbonic acid, and the energy of this re-

FIG. 26.



action raises the temperature of the carbon to a red heat, at which the carbonic acid is decomposed by taking up an additional equivalent of carbon, and carbonic oxide gas flows up into the producer. The heat of the lower layer of fuel causes the hydro-carbon gases in the upper to distil, so that a mixture of various inflammable gases and nitrogen becomes available for use. The gases rise into the furnace, which they enter, accompanied by the proper quantity of air, and unite with it, much as we see in an ordinary Bunsen burner. It is obvious that the intimacy with which the gas and the air may be made to mix, the relative proportion of each, and total rate of combustion, must be capable of the most exact control.

There is one method by which the combustion of solid fuel on ordinary grates may be ameliorated, and that is by the use of forced draught. The feeble pressure obtainable from an ordinary chimney necessitates thin and loose layers of fuel, but when air can be blown in, the layers may be increased in depth, and made more compact, so that the air is brought into more intimate contact with the combustible. By this means the quantity of air may be reduced to the theoretical amount, and the temperature of the furnace exalted in proportion.

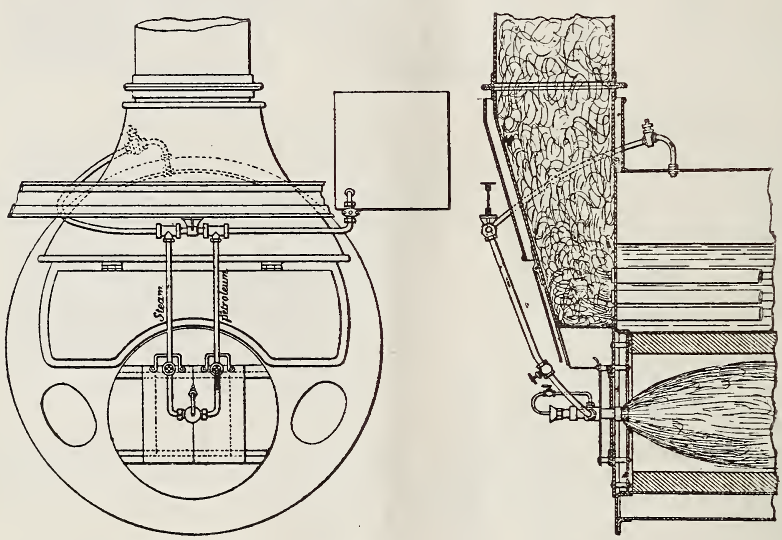
Little or nothing has been done to investigate the specific heat of gases at high temperatures, so that the uncertainty of calculations depending on an accurate knowledge of this property must still remain.

The investigations of St. Claire-Deville have revealed that, at high temperatures, compound gases become resolved into their elements, and that chemical combinations cease to take place. This phenomenon is called "Dissociation."

According to laboratory experiments, water and carbonic acid commence to dissociate at about 2,500° Fahr. absolute, and this action has an important bearing upon the temperature which a furnace is capable of attaining, although it evidently does not fix the limit, because it is certain that wrought iron and platinum can be melted in a coal fire, although the fusing points of the metals is about 3,500° absolute. We shall probably not be far wrong if we assume 4,000° absolute to be the superior limit of temperature of any furnace, a limit which, if the theory of dissociation be correct, can never be surpassed. The invention of a trustworthy pyrometer will alone be able to yield more definite information on this subject.

We may assume that the specific heat of coal, and of the products of combustion at constant pressure, are the same as that of air, namely, ·238, and it is highly probable that by the use of forced draught, of properly constructed grates, or of powdered, liquid, or gaseous fuel, it may be possible to ensure perfect combustion with only the quantity of air required to supply the exact weight of oxygen necessary to combine with the elements of the fuel. Under such circumstances, it is not difficult to calculate the temperature of the

FIG. 27.



furnace when we know the units of heat a pound of the fuel is capable of yielding, for it is only necessary to divide that value by the product of the weight of fuel and air into the specific heat, and add the quotient to the temperature of the air. Hence—

$$\text{Rise of temperature} = \frac{\text{Units of heat.}}{\text{weight of complete fuel} \times \cdot 238}$$

Take the case of Durham coke, for example—

$$\text{Rise of temperature} = \frac{13640}{(1 + 11\cdot 5) \times \cdot 238} = 4{,}588^\circ$$

and here we are at once met by a consideration which too often escapes notice, namely the effect of the pressure of the atmosphere under which we live on all the operations which we perform. The effect of combustion is to convert solid fuel into an immensely greater volume of gas; 1 lb. of Newport steam coal, for example, when burned with the least possible air, produces 147 cubic feet of various gases at 32° Fahr., or 492° absolute. If the temperature of the furnace rises from 50°, or 510° absolute to 5,376° absolute, the volume will be increased in the proportion of the absolute temperatures, or as $\frac{5376^\circ}{492^\circ}$ or a little more than eleven-fold, so that each pound of coal will yield 1,606 cubic feet, and in order to make room for this volume, the atmosphere must be moved aside at the cost of work = 1,606 cubic feet × 144 sq. in. × 14·7 lbs. =

3,400,100 foot-pounds, equal to the conversion of 4,404 units of heat, or 30 per cent. of the whole heat of combustion. If the action could be carried on in vacuo, there would be no appropriation of heat to the work of displacing the air, and then the temperature of the furnace would be much higher, namely, in the case of Newport steam coal, it would rise from 5,376° absolute to 7,362° absolute, an increase of 36 per cent. The co-efficient for the specific heat of gases which we have employed allows, as you may remember, for this external work done during expansion.

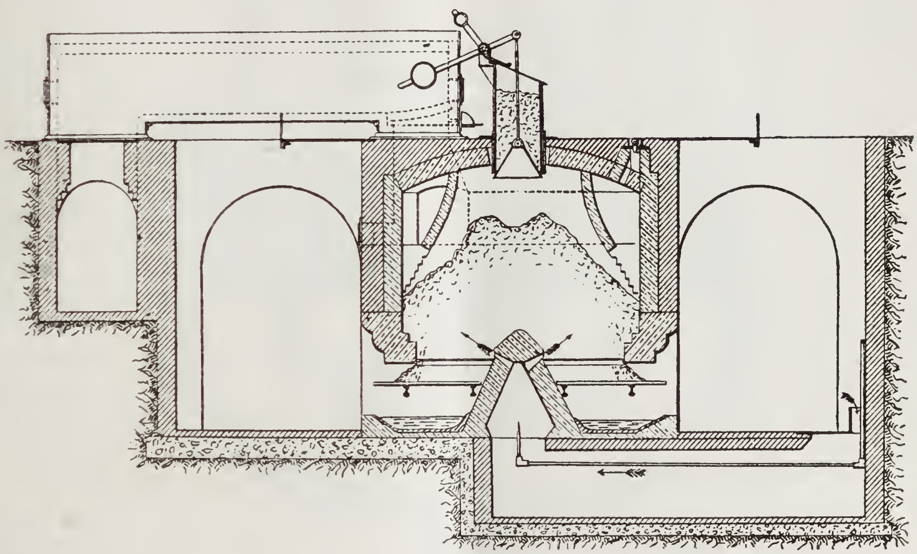
In any practical applications of fuel, we cannot arrange for the products of combustion to escape at a lower temperature than that of the surrounding air, and generally the temperature is much higher. Assume, as an extreme case, that the products of combustion have fallen to 50°, or 510° absolute, the gases will have shrunk to

$$\frac{147 \text{ c. ft.} \times 510^\circ}{492^\circ} = 152 \text{ cubic feet,}$$

and the work done will be 152 c. ft. × 144 sq. in. × 14·7 lbs. = 322,500 foot-pounds, corresponding to 418 units of heat, or nearl 3 per cent of the total heat of combustion. The work expended in displacing the air in the furnace is restored again as the gases cool, but the final loss, just calculated, s complete and irrevocable.

What, then, is the limit of efficiency in t combustion of fuel?

Fig. 28.



We must apply Carnot's theory, and assuming that 4,000° absolute is the maximum temperature to which we can attain, and 510° absolute the lowest, we have—

$$\frac{4000^\circ - 510^\circ}{4000^\circ} = \cdot 872$$

that is to say, under the exceptionally favourable circumstances I have taken, there must be a loss of 13 per cent. It may not, at first sight, be very apparent why the high temperature of the furnace should increase the efficiency when the smoke escapes at the same temperature in either case, and the same quantity of heat is yielded by combustion, but the explanation is simple. The cause of the reduction of the temperature of a furnace is the introduction of an excess of air, this air passes out by the chimney, and carries off heat in proportion to its weight; hence, in all cases where it is desired to attain the highest efficiency in the use of fuel, the aim must be to use as little air as possible, so as to raise the temperature of the furnace to the utmost, and to cool down the smoke usefully as much as possible.

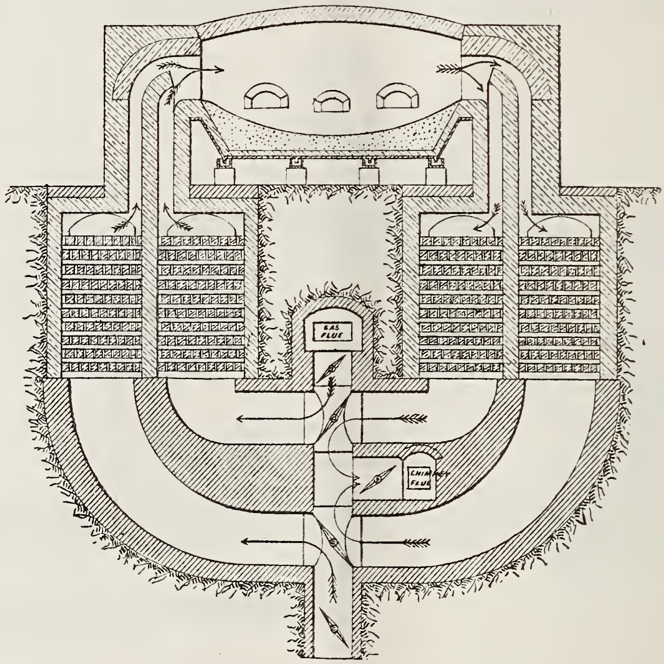
Under ordinary circumstances, at present at least, 50 per cent. excess of air is admitted into furnaces, and the chimney temperature rarely falls below 400°; this reacts unfavourably on the duty of fuel at both ends of the operation. Supposing 16·5 lbs. of air admitted to Newport steam coal the rise of temperature of the furnace would be reduced to—

$$\frac{14143^{u}}{17{\cdot}5 \times {\cdot}238} = 3396^{\circ}$$

and the smoke being at 860° absolute, the efficiency will $\dfrac{3906^{\circ} - 860^{\circ}}{3906} = {\cdot}78$, or 78 per cent., and the water evaporated would be $14{\cdot}64 \times {\cdot}78 = 11{\cdot}42$ lbs. per pound of coal from, and at 212°, which is very nearly the duty to which a good boiler can attain.

According to Carnot's doctrine, the temperature of the products of combustion should be reduced as low as possible, in order to attain the most economical results. In steam boilers it is possible, and practicable, to reduce the temperature to very little above the temperature of the feed-water supplied, because it is more economical to produce the necessary draught by means of a blower than by means of a hot chimney. From experiments made by the Admiralty, it appears that a pressure of air equal to a column of water 1 high produces a very strong draught—much greater than that due to a chimney fitted with a steam blast. We have seen that one pound of coal requires practically 18 lbs. of air to consume it; the volume of this at 50° = 231 cubic feet, and a pressure of 1″ of water, represent

FIG. 29.



5·2 lbs. per square foot, hence the work done in forcing in the air will be 231 × 5·2 = 1,200 foot-pounds. Suppose we have a blower, driven by a small engine consuming 5 lbs. of coal per indicated horse-power per hour, and suppose the blower does only 50 per cent. duty, we should have 2,400 indicated foot-pounds, and if this is done in a minute, then the units of heat absorbed by the engine would be :—

$$\frac{5 \text{ lbs.} \times 14{,}143^{u} \times 2{,}400 \text{ foot-pounds}}{60^{u} \times 33{,}000 \text{ foot-pounds.}} = 88^{u}$$

If the boiler had depended on chimney-draught, the temperature of the smoke must have been at least 400°, and the loss of heat = 19 lbs. × ·238 × 350° = 1,582 ^{u}, or eighteen times as much as the blower would consume. But suppose that by the use of forced blast we were able to arrange a feed heater, so as to reduce the temperature of the chimney to 100°, or only 50° above that of the cold water fed in, then the heat saved per pound of coal would be 19 lbs. × ·238 × 300 = 1,356 units more than fifteen times the heat absorbed by the blower, and competent to raise the 10 lbs. of water fed in per 1 lb. of coal 135.6°, a temperature still far short of that of the boiler. Two things are apparent from this consideration, namely, first, that decided economy will arise from blowing air

into boilers by engine-power, instead of drawing it in by means of a chimney; and secondly, that the feed water-heater should be detached from the boiler, and made to do its work at the lowest temperature practicable.

In furnaces used in the various arts, such as in metallurgy, in glass, and chemical manufactures, it is, generally, impossible directly to reduce the temperature of the smoke to economical limits. In blast furnaces, the intense heat at the boshes is, in a great measure, taken up by the mass of fresh materials continually being added at the top, but in most cases, especially where steam is not required, the regenerative system has to be adopted.

The regenerator was, I believe, invented in the early part of this century, by Stirling, for his hot-air engine. The principle is this, The hot body ejected from the heat-engine passes through a vessel filled with metal plates, bricks, or any other substances presenting a large surface of contact, and being good absorbers of heat. The consequence is, that one end of the regenerator, that nearest the engine, becomes highly heated, while the opposite end is comparatively cool. After a time the flow is reversed, and a cold current, which it is desired to heat, sets in towards the engine, and takes up the heat which the flow in the opposite direction has left in the regenerator.

The late Sir William Siemens adopted this system to furnaces working at high temperatures (see Fig. 29, page 654). He conducted the still glowing products of combustion to the chimney through chambers filled with fire-bricks, built up in reticulated fashion so as to present a large surface. The chambers were arranged in pairs, and the passages to them were controlled by valves. The air for the supply of the fire was led through one pair of chambers, and the gas through another, the valves being so manipulated that the flames would pass for an hour or two down chambers A, while the air and gas passed upwards through chambers B; then the currents would be reversed, and the air and gas would enter by chambers A, while the products of combustion descended by B. The chambers were made so deep that the maximum heat of the bricks extended a good way below the surface, and the duration of the flow of air and gas was so regulated that the layers of bricks nearest the furnace were not appreciably cooled, so that the temperature of the air and gas entering the furnace was practically constant. One end, therefore, of the regenerator was always at a constant high temperature, and the opposite end at a constant low one, the maximum heat of the space between oscillating up and down, according as the cold current or the hot was passing through. It will be readily understood that such an arrangement must lead to a regular increase of heat in the furnace each time the current of air and gas is reversed. Imagine the furnace started for the first time. The air and gas would come up to the point of combustion cold, they would be increased in temperature by the heat due to the chemical reaction, and would communicate the surplus heat to one pair of regenerators, A. On reversing the valves, the fuel would enter the furnace at a high temperature, the heat corresponding to the energy of combustion would be added to this, the flame would be hotter, and regenerator B would be more highly heated than A. On again reversing, the fuel would reach the hearth still hotter than at the previous turn, and the temperature of the flame would be again increased. A repetition of this process would lead to temperatures which no material, however refractory, would stand; but here dissociation steps in and puts a salutatary limit to the temperature which can be attained, a limit which we have assumed to be about 4,000° Fahr. absolute. The effect of the regenerators on the duty of the furnace is easily calculated. The temperature of the products of combustion leaving the regenerator is reduced to about 250° Fahr., or 710° absolute, and this fall has taken place in heating up the air and gases entering the furnace, and therefore, in doing useful external work; hence, we must consider the furnace and the regenerator as an engine working between our assumed maximum of 4,000° absolute and a minimum of 710°; consequently, the duty to be expected from the fuel will be

$$\frac{4{,}000^\circ - 710^\circ}{4{,}000} = \cdot 82.$$

Without the regenerator, the product would have escaped at a bright red heat, at least, 1,500° or 1,960° absolute, and the duty would have been $\frac{4{,}000^\circ - 1{,}960^\circ}{4{,}000} = \cdot 51$; hence, the regenerators secure an economy of 31 per cent.

In a recent paper read at the Iron and Steel Institute, Mr. Siemens stated, that careful experiments with an ordinary reheating furnace, using solid fuel, and a regenerative gas furnace, shewed an economy of 33⅓ per cent., which approaches very closely to the result deduced from these purely theoretical considerations.

The regenerative principle is capable of application wherever the products of combustion are not reduced directly to a very low temperature, as they may be, for example, in steam boilers. Thus, the waste heat of a Crampton furnace has been utilised in heating the air and fuel before it enters the furnace, and in raising steam, while Mr. Urquhart has applied the principle partially to warming some of the air as it enters the firebox. In his arrangement, only a portion of the air required enters with the jet of petroleum, the rest is admitted through passages made in the lower part of the brick oven, through apertures in the ash-pan; the heat, which would otherwise produce very little effect on the boiler, is thus made profitable use of.

APPLIED CHEMISTRY & PHYSICS SECTION.

Thursday, April 23, 1885; the Right Hon. LORD THURLOW in the chair.

The paper read was on—

THE CHEMISTRY OF ENSILAGE.

By FREDERICK J. LLOYD.

At what period of the world's history the custom of storing food in the ground originated, it is impossible to say, but it seems certain that holes in the ground were originally used to preserve grain unchanged, long before any buildings were constructed for that purpose. It is only within recent times that we have evidence of the preservation of food in such pits, by fermentation. Out of this custom has arisen the more modern custom of preserving food in properly constructed receptacles, termed silos. The substance so preserved is termed silage, and the process spoken of as ensilage, and for the sake of brevity I shall use the verb "to ensile." My endeavour to-night will be to describe the changes which a crop suffers in a silo, during its conversion into silage.

When any green vegetable is cut, and allowed to lie on the ground damp, it softens, rots, or decays and stinks, and this is a process of oxidation. The oxygen necessary for these changes is supplied by the atmosphere, which consists, roughly speaking, of 21 parts of the gas oxygen, and 79 parts of the gas nitrogen. If, however, a similar vegetable, when cut, is placed in an atmosphere devoid of oxygen, say in an atmosphere of carbonic anhydride, then, as it cannot oxidise, it does not decay. Changes, however, take place while in this atmosphere of carbonic acid, and those changes we term fermentation.

In order to realise what takes place in a silo, it is first necessary to understand what substances are put into the silo, and what changes are taking place in a plant while it is growing. The object of a plant is to produce seed. To this end it first stores up in its tissues the substances necessary for the production of that seed, and subsequently the seed is formed out of those stored up materials. From the atmosphere, by means of the green colouring matter of the leaves, the plant absorbs carbonic anhydride, and starch is produced. This starch is insoluble, hence, when required in a distant part of the plant, it is converted into sugar which is soluble, and carried in this soluble condition through the tissues of the plant. During the growth of the plant it serves to build up new cells, being converted into cellulose, but in the latter stages of growth it accumulates in the seed, being converted into starch. The roots of the plant are, meanwhile, active in accumulating nitrogen. The nitrogen is absorbed from the soil as nitric acid, present as soluble nitrates, and in the tissues of succulent green vegetables these nitrates abound. This nitric acid, which is a compound of nitrogen and oxygen, passes through a variety of changes, the oxygen being gradually replaced by hydrogen, and combining with organic matter. Amido acids are formed, subsequently amides, in which the nitrogen is combined with two atoms of hydrogen, and with organic acids, and as the plant matures, these amides become converted into albumen, which is finally deposited in the seed. The framework of the plant, the walls of the cells and the woody stems, are composed of cellulose and so-called woody fibre.

Now, no sooner is the plant cut than its life as a whole is checked, and the circulation of the materials in the tissues is rapidly brought to a close. But the life of the individual cells is not immediately destroyed, and these carry on their vital function for a short period. If, therefore, a crop is carted to a silo as it is cut, its vital functions will continue in the silo, hence the first possible changes which can take place in a silo, are those changes due to the natural growth of the plant cell.

It will be evident that crops when placed in the silo may vary greatly in composition. Green maize will be cut when the plant is gathering and utilising in its growth the

substances it absorbs, the nitrogen will be present partly as nitrates, as amido acids and amides, only slightly as albumen. As the starch is formed, it is rapidly converted into fresh cellulose to build up the growing plant. Such will be the condition of all crops cut in the early stages of their growth. On the other hand, a crop cut when the plant has reached maturity, as is the case with clover, and should be the case with meadow grass, when the seeds are formed and nearly ripe, in such plants, instead of nitrates, amido acids, and amides, the nitrogen will be present as albumen, and the sugar being no longer utilised in the growth of the plant will be stored up as starch. These represent the extremes of chemical composition so far as is dependent upon the period of growth, and it is as well that we should at once realise their significance. The nitrates, amido acids, amides, and cellulose of early growth are substances of very slight, if any, value as food for animals, whilst the albumen, starch, and sugar of mature growth are the essential nutritive constituents of all food.

Not only, then, do substances ensiled differ materially in composition according to the stage of growth, but they will also differ considerably according to their condition. Thus a crop cut in wet weather, or early in the morning when the dew is on it, if carted direct to the silo, will have an excess of adhering moisture. If cut in midday, in the sunshine, and at once ensiled, there would only be its natural moisture. Again, if cut and partly converted into hay, the plant before being pitted will have undergone the cellular changes which have been mentioned, and will have lost much moisture. Or should rain be allowed to fall upon it after cutting, the soluble constituents will be partially washed out of the plant and diminish its nutritive value before ever it is placed in the silo. Manifestly, there are a variety of conditions which a crop may be in before it is ensiled, and many of the substances which have been attributed to ensilage have probably had nothing to do with changes taking place in the silo, but were present in the substance when ensiled.

It will thus be seen, that the chemical composition of a plant changes, and its value as food for animals increases as the plant approaches maturity, and this must guide us in deciding at what period in its growth a crop should be cut and placed in a silo. With some few crops like green maize, it is impossible to wait until the state of maturity is reached, and experiments are wanted to show at what period preceding this state of maturity such plants are best fitted to be ensiled. Of the best condition for a crop when pitted, there is no doubt it should have as little extraneous moisture as possible.

A crop, when placed in a silo, has all its parts surrounded by the atmosphere, and the quantity of the atmosphere will depend partly on the condition or dryness of the crop when ensiled, partly on the method of ensilage adopted. Thus the portions of a crop of ripe red clover, ensiled long and dry, would be surrounded by far more atmosphere than the parts of a chaffed crop of green maize. Further, with a crop which is placed in a silo in small portions at a time, not being subject to a great superincumbent weight, and only pressed down in the necessity of spreading the stuff evenly, the atmosphere will be present in far greater relative quantities than where the silo is filled at once, or several men ram and stamp down the crop into a compact mass. All the changes which subsequently take place in the silo primarily depend upon, and are determined by, this proportion of atmosphere to crop, or more correctly speaking, by the oxygen contained in this atmosphere. Hence, where there is a maximum supply of oxygen, the resulting silage is at one extreme, and where there is a minimum supply of oxygen, it is at the other extreme of the infinite varieties of silage which have been produced.

We must now revert to the changes taking place in the plant. As previously stated, the chief function of the plant is to absorb carbonic acid from the air, liberating oxygen, and resulting in the formation of starch. The presence of sunlight is essential for this change. In the dark, this process is stopped, and the plant, to quote Prof. Huxley, "undergoes oxidation, and gives off carbonic anhydride." "There is every reason to believe that the same process of oxidation and evolution of carbonic anhydride goes on in the light." Once grasp these facts, and the changes which take place in the silo are no longer mysterious. Let me again state them. The plant, living in the sunlight, absorbs carbonic acid from the atmosphere, and starch is formed, subsequently it absorbs oxygen from the air, and the starch is changed into sugar. This latter process is one of oxidatien, and, as is well known, oxidation is invariably accompanied with the production of heat. When, therefore, a crop is cut and placed in a silo, provided the individual cells have not been destroyed in the process

of ensiling, these will continue to exert their action so long as their is oxygen to convert the starch into sugar, or starch enough to utilise the oxygen present. These changes are accompanied by heat, and, as we know, not long after a crop, or portion of a crop is placed in a silo, it rapidly rises in temperature. The amount of heat produced will be greater in proportion to the amount of oxygen present, so that in a thin layer of unpressed long clover we get a maximum amount of heat, and if this heat is developed in a comparatively dry substance, it may raise the temperature of the whole mass to between 120° and 150° Fahr. But where, from causes previously pointed out, there is less oxygen, the heat developed is less, and when developed in a wet material, it can only raise the temperature of the mass to between 80° and 90° Fahr. It must be clearly understood that the temperature is no indication of the amount of heat developed, for a given quantity of heat would raise a dry silage to a far higher temperature than it would raise a wet silage. Hence we cannot state, even upon *a priori* grounds, that the higher the temperature the greater must have been the oxidation or destruction, moreover, chemical analyses prove that it is not so.

This rise in temperature is associated not only with the absorption of oxygen, but with an evolution of carbonic anhydride, so that the atmosphere surrounding the plant gradually changes from being a mixture of oxygen and nitrogen to a mixture of carbonic anhydride and nitrogen, with more or less residual oxygen. Thus, according to the substance ensiled, and the method of ensiling, the resulting silage will, at this stage, come under one of three heads.

(*a.*) When ripe material, containing much starch and comparatively little moisture, has been surrounded with an excess of oxygen, the whole of the starch will be converted into sugar, and the gases will be oxygen, carbonic acid, and nitrogen.

(*b.*) When similar material has been surrounded with less oxygen, only part of the starch will be converted into sugar, and the whole of the oxygen absorbed, the resulting silage contains sugar and a little starch, and the gases present will be carbonic acid and nitrogen.

(*c.*) When unripe or damp material, containing small quantities of starch, has been surrounded by a small quantity of oxygen, part only of the starch is converted into sugar, and the silage will contain starch, sugar, and the gases be oxygen, carbonic acid, and nitrogen.

The following table shows these conditions at a glance:—

	Substance.	Gases.
(*a*) ...	Sugar.	Oxygen, Carbonic acid, Nitrogen.
(*b*) ...	Starch, Sugar.	Carbonic acid, Nitrogen.
(*c*) ...	Starch, Sugar.	Oxygen, Carbonic acid, Niirogen.

The conditions (*a*) are very seldom, if ever, realised in a silo, unless partially made hay is placed into the silo. But they are realised when wet grass is made into a hayrick, and they then result in the brown burnt hay, saturated with acetic acid, which most farmers are acquainted with.

The conditions (*b*) ought to result in what is termed "sweet" silage, though they do not invariably.

The conditions (*c*) invariably produce sour silage. If this sour silage is properly made, according to the conditions which have been set forth by M. Goffart and others, its acidity will be due to lactic acid. But when butyric acid is formed, the state of wholesome fermentation has been passed, and a process of decomposition has set in. Sweet silage and lactic acid silage are the only two substances deserving the name of silage, or worthy the attention of the farmer. I shall now endeavour to describe the conditions required for, and trace the chemical changes taking place in, the conversion of crops into sweet and sour silage respectively.

Professor Tyndall, some years since, demonstrated by striking experiments how the atmosphere is crowded with germs of moulds, ferments and bacteria. It is easy to prove that every crop placed in a silo, as well as the atmosphere surrounding it, is more or less covered with these minute organisms, which need only the conditions necessary for their growth in order to rapidly develop. These conditions are threefold: a suitable food to live upon, a suitable atmosphere to breathe, and a comfortable temperature, for some are more susceptible to changes of temperature than the most delicate among us.

These microbes may be divided into two classes:—

1. There are the germs of the ferments proper. These develop in an atmosphere of carbonic acid, and their action is continuous, but

they cannot resist a high temperature, while their activity is limited within narrow zones of temperature. Of these ferments only three need receive our attention. The acetic acid ferment converts alcohol into acetic acid, changing it, firstly, into that powerfully smelling and pungent substance "aldehyde." The lactic acid ferment converts sugar and starch into lactic acid, and the butyric ferment or vibrios convert lactic acid or sugar into butyric acid.

2. There are the germs of the ordinary moulds with which we are familiar. Their normal life is in oxygen or air, and probably a very high temperature, approaching that of boiling water, is required to destroy them. But Pasteur has shown that the germs of these moulds can live in carbonic acid a life similar to that of a true ferment, and convert sugar into alcohol, but, he states, "such a life is not continuous, as is the case with an ordinary fermentation."

The changes in the silo, however, are not limited to those brought about by these microbes. Lechartier and Bellamy* have shown that the cells of the higher plants are capable, when immersed in an atmosphere of carbonic acid, of acting upon the sugar they contain, and converting it into alcohol. To summarise, then, the living plant cell contains starch, it absorbs oxygen in the silo and converts this starch into sugar, liberating carbonic anhydride, subsequently it converts the sugar into alcohol. Side by side with these changes natural to the plant, are those due to the action of various ferments.

These changes are shown chemically by the following diagram:—

CHEMICAL CHANGES IN SILAGE.

Starch + Water = Sugar.

$$C_6 H_{10} O_5 + OH_2 = C_6 H_{12} O_6.$$

Sugar = Alcohol + Carbonic Anhydride.

$$C_5 H_{12} O_6 \quad 2 (C_2 H_6 O) + 2 (CO_2).$$

Alcohol + Oxygen = Aldehyde + Water.

$$C_2 H_6 O + O \quad C_2 H_4 O + OH_2.$$

Aldehyde + Oxygen = Acetic Acid.

$$C_2 H_4 O + O \quad C_2 H_4 O_2.$$

Sugar = Lactic Acid.

$$C_6 H_{12} O_6 \quad 2 (C_3 H_6 O_3).$$

Sugar = Butyric Acid + Carbonic Acid and Hydrogen.

$$C_6 H_{12} O_6 \quad C_4 H_8 O_2 + 2 CO_2 + H_4.$$

Lactic Acid = Butyric Acid + Carbonic Anhydride + Hydrogen.

$$2 (C_3 H_6 O_3) = C_4 H_8 O_2 + 2 (CO_2) + H_4.$$

* *Comptes Rendus*, 1869, p. 366 and 466.

We are now in a position to sum up rapidly the changes which take place in a silo so far as the carbo-hydrates are involved.

I. Where there is an excess of oxygen we have already traced the formation of starch, sugar, and carbonic acid with some residual oxygen and nitrogen. As the quantity of carbonic acid increases the power of the mould cells, and of the cells of the plant to convert sugar into alcohol becomes manifest, and the action of the ferments also begins. The *mycoderma aceti* attacks the alcohol and converts it into acetic acid, and the lactic ferment sets to work to convert some of the sugar into lactic acid. The conditions which favour the butyric ferment are not present. While these changes are taking place, the temperature of the silage is still rising from the formation of sugar, and the production of heat rapidly outstrips the action of the ferments, until at last the mass reaches a temperature at which these ferments cannot exist, viz., 122° Fahr. The temperature, however, still continues to rise, provided there be sufficient oxygen until the vitality of the cells themselves is destroyed, and this appears to be at 150° Fahr. So rapid was this rise in temperature in one instance, that the alcohol had only undergone conversion into aldehyde when the action of the ferments was suddenly stopped. Such are the conditions for the production of "sweet" silage, and it necessitates, therefore, a dry substance, an excess of oxygen, and a temperature above 122° Fahr. To obtain these, Mr. George Fry lays down the following condition, that the substance when placed in a silo should not contain more than 75 per cent of moisture, must be in active and mature growth, so that the cells may be alive and contain sufficient starch when ensiled, and lastly that the silo be filled slowly. For further particulars I must refer to Mr. Fry's book on the subject. From the time the silage reaches the temperature of 150° Fahr. until the time when it is taken from the silo, it undergoes no change, hence we should find in it still unaltered the sugar formed by this oxidation, and Messrs. Cross and Bevan, have so found no less than 6 per cent. of sugar in a sample of sweet silage. As sugar would have been destroyed by further change its presence is conclusive proof that no such change had taken place. The composition of clover silage obtained in this manner is shown by analyses Nos. I. and II. No. I. was silage made by Mr. James Howard in his new silo. No. II. silage made by Mr. George Fry.

Now if we attempt to make sweet silage, and fail to reach the desired temperature of 122° Fahr., so that the ferments are not destroyed, the alcohol which has been formed will be mainly converted into acetic acid, while the remainder of the sugar will be converted into lactic acid.

Analysis No. III. shows the composition of such a silage, being from the same silo and part of the same crop as No. II. It will be seen that even under these conditions the quantity of acid formed is less than is formed in sour silage, owing to the high temperature attained being less favourable to the growth of the ferments than is the lower temperature of sour silage, and also to changes which have yet to be described. But when we compare the composition of the dry matter, it will be seen how considerable has been the destruction of carbo-hydrates in the formation of these acids.

II. Next we have to consider the changes which take place where there is a deficit of oxygen. To commence with, they are exactly similar to those changes which take place where there is an excess of oxygen, but the oxygen soon failing, the starch is only partially converted into sugar, and very little alcohol is formed, moreover, the rise in temperature is not sufficient to kill the ferments. These little organisms, therefore, continue their work uninterrupted, so long as the substance is left in the silo, or so long as there is any starch or sugar for them to act upon, and as the amount of alcohol produced in the sour silage is always slight, so the amount of acetic acid is small as compared with the amount of lactic acid. This is well seen in analyses Nos. IV. and V.

So far we have considered only the changes in the carbo-hydrates; let us now consider the changes in those compounds containing nitrogen, about which so much has been written, though so little is known.

It had been taken for granted that the whole of the nitrogen in the plants ensiled, and in the subsequent silage, existed as albumenoids, until Professor Kinch pointed out the error; and nearly every analysis of ensilage which has been made is useless. That changes take place in the nitrogenous substances is evident, for ferments require nitrogenous substances as food, and, therefore, the greater the amount of ferment life which has taken place in a silo, the more will the nitrogenous substances of the plant have been split up. The first change appears to be the conversion, by long contact with the acidity of the silage, of insoluble albumen into acid albumen, which passes into solution when the silage is treated with water. Hence we find, as a rule, that the greater the quantity of acid present, the larger the proportion of soluble albumen, thus, in No. V., one-half the albumen is soluble, while in No. IV., with a smaller proportion of acid, one-fourth of the albumen is soluble. In the sweet silages, even when it was endeavoured to make sweet silage without success, the soluble albumenoids bear a much smaller proportion to the insoluble. Next, there are formed in silage, peptones, nitrogenous compounds similar to those produced in the stomach of an animal when digesting albumenoids. Thus the silo plays the part of a digesting machine, and this may help us to elucidate why silage has proved so digestible and beneficial a food. The process of change does not stop with peptones, there is a further splitting up into amides and into many other compounds which have so far baffled my efforts to isolate them. I believe, however, that in some silages I have obtained urea, while the existence of ammonia as salts of ammonia has been proved beyond doubt by Professor Richardson, of the United States Agricultural Department, as also by myself. I have never detected, however, nitric acid. Further, as it is known that the latic acid ferment has the power of forming lactic acid, out of the destruction of nitrogenous compounds, it is probable that lactamide is present in most sour silages.

The insoluble albumen, the soluble albumen, and the peptones, will act as nitrogenous food to the animal body. Whether the amides do so, is still a matter of doubt. Weiske and Schulze* from recent investigations believe they do, but it is generally held that they do not.

Thus it will be seen that change takes place necessarily in the convertion of crops into silage, and with that change loss. The loss is least with sweet silage rapidly made, greater with sour silage, greatest with silage which undergoes butyric fermentation, and the value of the substance as food decreases in a similar manner.

The extent of the loss has never yet been shown, and many of the estimates are ludicrous; the loss in weight is mainly due to the evolution of water vapour, the maximum loss of material which could accrue would be the total conversion of the carbo-hydrates other than cellulose into carbonic anhydride and water. That this never occurs we know, and as the carbo-hydrates seldom amount to over 40 per

* Zeit. Biol. 20.

cent. of the dry matter, the loss at most can seldom exceed 30 per cent. Personally, I do not believe it is ever anything approaching that.

In attempting to estimate the value of silage, we must remember that by supplying a long felt want among farmers, namely, a succulent food at a time of year when no succulent food can be growing on the farm, it possesses a value as fodder which is not due solely to its chemical composition. Experience has shown, moreover, that it not only supplies the place of roots, but also of the hay chaff which is usually given with those roots. Hence, if ensilage proves successful, its advantages will be twofold—it will do away with much of the anxiety of making hay, and leave land which would have been devoted to the growth of roots free for other crops. But it can never take the place entirely of roots and hay, if only for the reason that the food of cattle, like that of man, must be occasionally varied. In order, therefore, to obtain the true feeding value of ensilage, we must compare it with pulped roots and hay chaff made from the same grass or clover. This comparison I cannot now make, but there are some important differences between hay and silage to which attention may now be directed.

It is well known that the cellulose of the young and tender cells of a plant can be digested by an animal, but not so the older and tougher wood. Messrs. Cross and Bevan have shown that the difference between them is mainly one of hydration, and that we can, by depriving the cellulose of its water, convert it into so-called woody fibre. This change does take place in the rick, but it does not take place when grass is converted into silage. Some have thought that indigestible fibre was converted into digestible cellulose in the silo, and it is not impossible that this should happen, though, probably, it does not. There is a distinct advantage, none the less, in silage over hay, inasmuch as it retains the cellulose in a digestible condition. There is one great drawback in ensilage when compared with hay or roots, it will not keep, but becomes the prey of mould. I am convinced that the mould spores present in the silo are never killed, but remain inactive owing to the absence of air, and it is the penetration of air into the silage, whether in the silo or after it is brought out of the silo, that produces mould. Hence mould is always found at the top and sides of a silo, and to prevent it we must exclude the atmosphere. This it appears to me might be accomplished at least expense by placing on top of the wooden covering of the silo a very deep layer of some porous material like sawdust, or finely chaffed straw, so that the gases rising out of the silo might, to some extent, be retained, and drawn back again when the silage cooled. Some few silages I have seen which do not become mouldy, and from experiments made these appear to owe their immunity to one of two causes. Either they have been too dry or too acid.

A few words, in conclusion, on the feeding value of silage. For fattening animals there is no proof of silage being inferior or superior to the usual and drier winter feed of hay and roots. For cows in milk, the evidence on all sides is apparently in favour of sour silage, as producing more milk, not inferior in quality to that produced by a diet of swedes and hay. This increased flow of milk from cows fed with sour silage is a fact, the causes of which are, as yet, unexplained. It may be due to the acidity of the food, and this view is supported by the well known effect of brewers' grains in augmenting the flow of milk. It may be due to the nutritive compounds in the silage being in a more soluble, and hence more easily digested condition; or some of the substances formed in the silage may act as would a drug in accelerating the secretion of milk, but this would not explain its quality. It is undoubtedly remarkable that a substance which has apparently lost nearly all its carbo-hydrates should not only increase the flow of milk, but without diminishing the yield of butter. The only feasible explanation is that the lactic acid formed is as much a food as the sugar from which it was formed. Unfortunately, I know no physiological experiments which could either prove or disprove this theory. But we know that the butyric acid vibrios easily convert lactic acid into butyric acid, which is the essential fat acid of butter, and it may be that lactic acid lends itself specially to the cow for the same purpose. The subject, however, is worthy of further investigation.

While, therefore, it is impossible to make all crops into sweet silage, it is, so far as we can judge, not altogether desirable. Sweet silage, having suffered less loss than sour silage, will always be more nutritious, hence it will be best suited to fattening animals, while sour silage will be specially suited for milk production.

Such are the conclusions I have come to from my chemical study of silage, and you will notice that, in the main, they agree with the conclusions previously arrived at by Mr. George

Fry, from a physiological study of the subject. To him is due the honour of having first clearly realised the nature of ensilage. There is, however, much yet to be learnt, and accurate analytical, physiological, and feeding experiments are still required, before we shall fully realise the complicated changes which take place in the silo, and the more complicated structure and properties of that rapidly changing substance—silage.

ANALYSES OF SILAGE.

		No. I.		No. II.		No. III.		No. IV.		No. V.	
	Substance ensiled	Clover (sweet).		Clover (sweet).		Clover (sour).		Perm pasture (sour).		Maize (sour).	
		Natural	Dry	Natural	Dry	Natural	Dry	Natural	Dry	Natural	Dry
	Moisture	50·940	...	64·580	...	78·097	...	69·163	...	82·785	...
Soluble in water.	Free volatile acid (acetic acid)	·228	·466	·120	·339	·374	1·704	·428	1·391	·510	2·961
	Free non volatile acid (lactic acid)	·198	·404	·540	1·525	·410	1·873	·680	2·207	1·485	8·622
	Albumenoids[1]	·434	·885	·250	·702	·187	·850	·272	·885	·406	2·357
	Peptones,[2] amides,[3] and ammonia salts; Carbohydrates (sugar, &c.)	8·818	17·973	6·977	19·686	1·696	7·739	7·073	22·781	2·515	14·608
Insoluble in water.	Albumenoids[4]	4·287	8·739	3·194	9·012	2·019	9·219	1·047	3·398	·831	4·825
	Digestible carbohydrates	18·025	36·739	12·223	34·466	8·961	40·921	10·553	34·294	6·107	35·482
	Indigestible carbohydrates (woody fibre)	13·091	26·686	9·354	26·464	6·711	30·639	8·736	28·394	3·705	21·526
	Mineral matter (less CO_2)	3·979	8·108	2·762	7·806	1·545	7·055	2·048	6·650	1·656	9·619
		100·000	100·000	100·000	100·000	100 000	100 000	100·000	100·000	100·000	100·000
	[1] Containing nitrogen	·069	·141	·040	·113	·030	·137	·043	·139	·065	·377
	[2] " "	·162	·330	·160	·442	·249	1·137	·367	1·184	·169	·981
	[3] " "	·379	·773	·160	·442	·045	·206				
	[4] " "	·686	1·400	·511	1·443	·323	1·475	·167	·539	·133	·772
	Per-centage of nitrogen present as albumenoids	58·25	...	63·26	...	54·5	...	36·39	...	53·95	...

DISCUSSION.

Mr. W. J. HARRIS, M.P., said this was certainly the best exposition he had yet heard of the chemical properties of silage. Up to the present, chemists had been rather running down silage, whilst practical men who had used it had known all along that they must be wrong. His impression was, that the agricultural chemists had not sufficiently taken into account the appetising qualities of the food; a food might analyse very well, and be extremely nutritious according to its constituents, but after all, the animal might not do so well on it as on a food which did not analyse so well. There was no doubt they were as yet only on the border of the truth as regards ensilage, which was one of the most important experiments with regard to English agriculture which had been made during this century. A Commission was now sitting upon it, which he apprehended would lead to very useful results, not only for England, but especially for Ireland, where the climate was eminently suitable for this practice, many fodder crops having been lost there through this discovery not having been made sooner. It was not a question simply of saving a crop, but of saving it at its very best. If you converted a crop into hay, the weather might prevent you doing so until the best period was past, and this point had been brought out very clearly in the paper, which showed that at a certain point the growth of the plant was at its best, and that either before or after it was not so good. He had cut grass for ensilage in several stages. Last year he cut the aftermath of a meadow which had not at all arrived at maturity, it being in a late country. It was in a green, flaggy stage before any seed was formed, and it did not turn out good ensilage, although it kept remarkably well. It scoured the animals, and was not nearly so good food as other samples he had tried. They had not heard much of the mechanical principles, but his opinion was that you might put the grass together in a tolerably wet state, and yet make sweet ensilage, for the heat, if you did not press it down too closely, would expel a good deal of moisture if you delayed putting pressure on the top. He preferred sweet ensilage to sour on the whole, though he had made both. This system gave immense advantages in cropping. Instead of waiting for the weather, the crop could be cut at the very best period. It also facilitated the clearing of the land, and an immense amount of labour might be saved by not having it all thrown

into one or two weeks; crops which came to maturity at different periods, being sown and ensiled as they became ready. The introduction of this system would perhaps induce farmers not to lay down so much land for permanent pasture. and would enable those who were now farming soil only fit for growing corn to make a more profitable use of it in the future. He had no doubt that next season would prove its utility in all its respects, and that if it were further studied by men like Mr. Lloyd, a great revolution might be produced.

Prof. KINCH said as the reader of the paper had pointed out the processes which took place in converting fodder into silage were due to the action of organised ferments, they were, therefore, physiological changes, and this would account for the great difference in the qualities of silage, and the many varieties which occurred. There were mainly two varieties, the sour and the sweet. The production of sour silage was due to the development of a large amount of heat during the process, the temperature being allowed to rise to 120° Fahr., which prevented the development of the particular ferments which were instrumental in producing lactic, butyric, and acetic acids, which were present in the sour form. The principal loss which occurred was due to the oxidation of the carbohydrates, but there were also chemical changes in the albumenoids which underwent a certain amount of transformation, and became converted in substances which were not unsuitable for animal food. It had been shown by analyses by Dr. Kohner, by himself, and others, that the principal portion of the nitrogen of albumenoids which was so decomposed was converted into ammonia, and of course in that form they were quite useless as food. The whole of them, however, were not so converted. In some recent analyses he found that when grass was converted into silage, 36 per cent. of the albumenoids had been degraded into non-albumenoid forms, 33 per cent. of which was converted into ammonia. In another case of cabbage silage, considerably less albumenoids were thus degraded; 66 per cent. of the total nitrogen non-albumenoid being thus converted, of this only 18 per cent. had been converted into ammonia, the rest being converted into amides, but it was very difficult to isolate these bodies and determine their exact nature. It had been found in various experiments that of the loss occurring in the conversion of fodder into silage, between 20 per cent. and 30 per cent. of the total dry matter was lost. It was very difficult to compare this loss with that which took place in making hay, no exact experiments having been made in that direction. Under the most favourable circumstances some loss occurred, probably not much, but when hay-making took place in bad weather, the loss was very serious, probably much greater than that which occurred in ensilage. One great advantage of this process was, that it could be carried out in bad weather; and he had examined some specimens so made, and found them perfectly good. The flavours which conferred the appetising qualities on ensilage were too subtle to be detected by chemical analysis.

Mr. H. M. JENKINS (Secretary to the Royal Agricultural Society) said he had already published what knowledge he had gathered in regard to ensilage, and he could not pretend to enter into the chemistry of the question, but there were one or two points he might shortly refer to. This process was not a new one, for fodder had been preserved above ground in buildings, or below ground in pits, for a long period, but it had been chiefly, and hitherto almost exclusively, adopted in those countries where they had a dry summer climate which prevented their growing succulent roots for winter use; in fact, it was the old story, that necessity was the mother of invention. He quite agreed in what had been said as to the importance of the physiological aspect of the question. They knew perfectly well that, with a certain amount of sauce, human beings could eat and digest much more nutritious matter than they could otherwise do, and so it was with the animals of the farm; but if one were to attempt to feed either human beings or animals on those sauces alone, they would soon find that a great deal of harm was done, and no good at all. Therefore, though it was necessary to attempt to gauge the feeding value of silage both by analysis and experiment, it must not be considered that either one or the other was the conclusive test; much more time must elapse and many more experiments be made with these substances, singly and in combination, in order to arrive at a just conclusion. One of the most successful experimenters on the Continent once told him that he never thought it safe to publish the results of any experiments until he had been prosecuting them for at least ten years, and, therefore, he hoped those interested in the question would not be too pressing in asking for definite results. The question of sweet silage had excited a good deal of attention, and too much praise could not be given to Mr. Fry for what he had done in that direction; but this question was still in its infancy. If, as Mr. Lloyd said, sweet silage could only be made when the substances contained 75 per cent. of moisture, which he apprehended meant both inside and outside, it would not be of much value to the British farmer, because if he could get his grass or other material with only that amount of moisture in it he would prefer to make it into hay. The chief use of the system, at any rate, would be to enable farmers to preserve crops in wet weather which otherwise could not be preserved at all. That was speaking generally; of course he should make an exception in the case of suburban farms, where the land was nearly all in grass, and where it was very important to have some nice food for winter feeding.

Dr. JOHN VOELCKER said as this was a question, to a great extent, of chemistry in which he was directly concerned, he would be forgiven for taking a

somewhat more critical view of the paper than previous speakers. Mr. Lloyd had traced different stages of plant development which ended in the formation of starch, sugar, and so forth, and also the stages through which the nitrogenous elements went, resulting in the successive formation of nitrates, amydal acids, amides, and, finally, albumen; but all chemists would agree that their knowledge on these points was still very crude, and that when they spoke about amides, they knew very little about them, and their conversion into albumenoids. The transformation of albumenoids into amides, through the process of ensilage, was also a point on which they were very much at sea. He missed altogether in the paper a record of careful demonstrations, showing the points in which chemistry really touched upon different processes of ensilage. Taking, first of all, the conversion of starch into the different cellular bodies, Mr. Lloyd said the plants absorbed carbonic acid from the atmosphere, and starch was formed, which was converted into sugar, this being a process of oxidation. The first formula on the second diagram on the wall gave the conversion of starch into sugar, but the process, as rightly described there, was by no means a process of oxidation, it was a process of starch taking up a molecule of water, which was metabolism, not oxidation; they were not dealing with quite such plain facts as were shown on the diagram. Three different stages were put forward, which resulted in different gases being formed, in one case, the oxygen being present in excess, in another in a smaller quantity, and in the other, it being deficient altogether. In the first, they were told that the sugar, no longer utilised in the growth of the plant, would be stored up as starch, and this starch was converted into sugar; but he would ask if the sugar, being no longer required by the plant, was stored up as starch, went back to its previous state, because if they looked at that in connection with maize they were told that a different process took place with that, because the maize did not proceed farther than the stage of cellulose? It was put forward that the starch was first converted into sugar, then cellulose, and then stored up as starch in the seed. But that was far from being the simple process described; it was really the great difficulty which agricultural chemists had to deal with, and required a great deal more knowledge on their part before they could discuss these things with any approach to certainty. Probably by the time they had done so, practical farmers would have settled their questions, and would be able to join with them, and come to some decided result. Then, Mr. Lloyd, speaking of butyric fermentation, said that when that began, decomposition set in. Of course, the whole process of fermentation, from the beginning, whether acetic or lactic acid, was produced, was one of decomposition; it did not merely set in then—it had been going on the whole of the time. Then they were told that when sweet silage was formed, the conditions favourable to the growth of the butyric ferment were not present, but they were not told what they were. With regard to the analyses which were given as throwing some light on the question of sweet silage, he would direct attention to the first analyses, because simultaneously with Mr. Lloyd, he had also made analyses of these samples. These results did not seem to him to make the subject quite so clear as was supposed. Mr. Lloyd said, if they failed to reach a temperature of 122°, the alcohol which had been formed would be converted into acetic acid, and the remainder of the sugar into lactic acid. The three samples were, one of Mr. Fry's, one of Mr. Howard's, and also a sample from their own silos at Woburn. The one of Mr. Fry's gave acetic acid ·12, lactic acid ·54; Mr. Howard's, acetic acid none, lactic acid ·47; and those from their Woburn silos, which reached a temperature of 125°, gave acetic none, lactic acid ·65. All these samples were *par excellence* sweet silage; and yet he found in them, in two cases, no acetic acid, and a considerable quantity of lactic acid, and even taking the second one of Mr. Lloyd's analyses, the acetic acid was ·12, and the lactic acid was ·54, which showed a decided preponderance of lactic acid as being an important matter in the manufacture of sweet silage. He was, therefore, loth to accept the supposition that that formula *B* was the one to produce sweet silage, and that only when the process failed, of which No. 3 was an example, did the alcohol go to acetic acid, and the remainder of the sugar to lactic acid. The lactic acid would depend on the amount of sugar originally in the crop, and that again depended on cultivating it at the right point of maturity. The great difficulty with maize was to get the sugar into it at all. When there had not been sun enough to ripen it, you might have maize with no sugar at all; but in favourable weather it would be different, and you might have very good silage. The action of the sugar, and the subsequent changes into lactic acid, was perhaps one of the most important ones to be looked into. In the fourth and fifth examples, the acetic acid was said to be small compared to lactic acid, but in Mr. Fry's it was the reverse. Then it was also said that the loss was less in the case of sweet silage, but that seemed to be an arbitrary statement, for which no definite data was given. It was only by turning out the whole of the soil and weighing it, and having analyses before and after, that any tangible conclusion could be arrived at as to the entire loss. The great difference between 19·6 and 7·74 showed a loss of about 12 per cent., but these were bodies soluble in water; and 40 per cent. and 30 per cent. of digestible and indigestible carbo-hydrates in No. 3 came to 10 per cent. more than the same constituents did in No. 2, so that if there were a loss in one part, there had been a gain in another.

Mr. Lloyd said that was a wrong method of arguing altogether. If you lost 12 per cent. calculated on the dry substance, you reduced 100 parts of

this to 88, and then when you calculated that 88 per cent. into 100, you raised the others.

Mr. CROSS remarked that the only constant constituent was the mineral matter, so that it could be seen pretty clearly that there was no loss at all, or only a very slight one.

Dr. JOHN VOELCKER said Mr. Cross was quite right in mentioning that, because mineral matter was always taken as the constituent which showed that the composition of the thing had not altered very much *in toto*. With regard to the conversion of starch into sugar, Mr. Lloyd said that went on for a short time after the crop was cut, and when put into the silo and gradually heated up; but there was not a single experiment to show that this actually did take place, and he was very doubtful indeed as to the presence of sugar and alcohol in silage at all. He held in his hand the last paper published by his father on the chemistry of ensilage, in which he stated that in no case was he able to detect even a trace of alcohol, and since then he had seen nothing reliable as to alcohol being found in silage. They had tested samples again and again for alcohol and sugar, and in none of them had they got any clear indication. Other things were said to be found in it, as urea, which he would suggest might be due to something adherring to the clover from some of the animals upon it, or to the people who trampled the stuff down. He was hardly in a position at present to mention the results of their own feeding experiments, but many of the statements seemed much in the form of assumptions. The whole question was a most difficult one, and needed a great deal more work both by agriculturists and chemists.

Mr. J. HOWARD, M.P., said he had listened to the paper and discussion with great interest, and perhaps would not be singular if he expressed the opinion that he had been somewhat lost in the maze of chemical science, or, at all events, of chemical theory. Mr. Lloyd had tabulated certain results, but he should like to ask him whether the knowledge of the chemistry of ensilage had advanced far enough to enable him to put a relative commercial value upon the different samples he had noticed, in the same way as was done by chemists in the matter of manures and feeding stuffs. If this could be done, it would be a considerable guide to the practical farmer. Mr. Lloyd had expressed a strong opinion that acetic acid silage was better for milk than sweet silage, and that the latter was better for the production of meat, and he should like to know whether that opinion was based on practical experience, or whether it was simply a theory. They were as yet merely on the threshold of this subject, and he hoped the work of the Commission, of which he had the honour of being a member, would result in the accumulation of a good deal of practical information, and also that the chemists would still pursue their inquiries more fully into the subject. He had always looked upon silage as an invaluable addition to feeding stuffs, and did not put it quite so low as Mr. Jenkins, who reduced it to the position of a mere condiment; it was far more than an appetiser. One great problem in the construction of a silo seemed to be to know when to arrest the process of fermentation, and all the chemical appliances had that object in view, so that when fermentation had proceeded to a certain point, either by weight, or some other means, it should be stopped. When he commenced his own experiments, he obtained a number of large glass jars, like the one on the table, which were filled, on the 14th of May last, with cut tares, which had since sunk to only about half the cubical contents. Every alternate jar was placed upright, and weighted, the others being turned topsy turvy, and in every instance with the jar turned topsy turvy, the result was sweet or alcoholic ensilage —alcoholic in flavour at any rate. Dr. John Voelcker said that alcohol had never been discovered, but his father certainly gave the three classifications of ensilage as sweet, alcoholic, and acetic. No exhaustive experiments had been carried out with respect to the temperature in silos, but next year he intended to devote his attention to that branch of the subject. He was perfectly satisfied that where proper means were adopted, the silo should be perfectly air-tight. In one silo made of iron, he placed a number of bull's eyes to watch the process of fermentation going on, and although the glass was put in as securely and tightly as possible, all round the little glass openings mould formed, although in no other part was there a trace of it. Evidence had also been given that day before the Commission that the slightest chink left near the door led to a very considerable amount of the silage becoming mouldy.

Mr. CROSS said his impression was that it would be affectation to suppose that there was any complete theory to account for the changes which took place in ensilage. There had been too much running after figures and numbers before they had ascertained the probable value of the evidence afforded by them, and he should agree decidedly with Dr. Voelcker in the diffident attitude he took up towards the results of chemical analyses generally. With regard to the explanation given of the fermentation as accounting for the phenomena, it occurred to him that too much emphasis was laid on the function of these organised ferments, leaving out of consideration the action of unorganised ferments, and the intrinsic chemical energy of the substances themselves, which he believed was a very great factor. Professor Bauer published a paper some years ago, in which he threw a great deal of doubt on the theories then current with regard to fermentation, attaching more weight to the intrinsic energy of the substances, and particularly to the favourable influence which the presence of water had on the chemical re-arrangements which followed in consequence of this energy. In considering the ques-

tion of a living substance and the elaboration of growth, it was obvious there was an enormous synthetic power of re-arrangement, and there could not be the slightest doubt that this was one, if not the chief factor in the changes which took place in the pit. Of course they knew the condition of the pit favoured such hydration changes. In some cases the substances would be almost in solution, whilst a dry crop was altogether removed from the influence of water molecules. He was rather surprised at the emphasis laid on the question of starch, for he had often examined fresh crops, and had never discovered any starch at all. If you took a plant in bright sunshine, and carefully examined it, you might find starch; but when working at Kew some years ago, with the assistance of a biological observer, they could never get starch as a permanent constituent at all. They found it was purely migratory; it would appear and disappear in a manner they could not account for; putting aside the question of seeds, in the whole stem of the plant they could never detect any. The question of the part played by oxygen, and the account given of the changes which took place, required a great deal more examination. If these had such important influences, they could be to a great extent controlled, and chemists who investigated these changes must expel the oxygen by displacement with carbonic acid, by exhaustion, or any other process, and thus they could determine whether oxidation favoured the changes which took place. The table of analyses would have been more easily grasped if they had been all calculated to some dry weight, or per-centage of water. He had already referred to the question of mineral matter, and if they calculated out the minerals to the per-centages of dry substances, the destruction of organic matter could not be very high. With regard to the carbo-hydrates being classed as soluble and insoluble, he had experienced great difficulty in separating these substances at all, and should like to know the method Mr. Lloyd had followed in settling the question. He had found that to separate carbo-hydrates even into soluble and insoluble was extremely difficult, and to separate them into digestible and indigestible, on the result of chemical analysis, in the present state of knowledge he believed to be quite impossible. Sufficient evidence of that was given by the question which had long vexed agricultural chemists on the digestibility of ligneous fibre. There was by no means a clear concensus of opinion whether these so-called ligneous fibres were digestible or not, though the balance of opinion was that they were. This was one of the most complicated and difficult of natural problems, and neither the chemist, the agriculturist, nor the physiologist alone, was capable of solving it. Probably the organisations which existed in Germany for scientific work were in a better position to attack problems of such complexity than anyone in this country, but at the same time they had an express opinion from the representatives of the Agricultural Society which showed that that body had a clear grasp both of what had been done, and of what still remained to do.

Mr. T. CHRISTY, referring to the remark on fodder containing 75 per cent. of moisture, said he believed Mr. Lloyd only intended to refer to the first portion of the pit that this fodder was dried in, to enable it to get up a certain amount of heat which would then cause the heat to pass through the whole mass. Again, with regard to the maize, there were a great variety of plants going by that name. If the sorghum were used, it would be found that sugar formed in it much more rapidly.

The CHAIRMAN said they would all agree that they had been very fortunate in listening to so many specialists gathered together on that occasion. It was a matter of great congratulation to agriculturists, and to the country at large, that the Government had sanctioned the appointment of a Commission to inquire into this important subject, for it was of the first importance to take every step to encourage the British farmer, if possible, to take advantage of any invention which might be for his benefit. He could not speak as a chemist, but he could, to a certain extent, as a practical farmer, for he had now for fifteen or twenty years farmed several thousand acres, not from necessity, as had lately been the lot of many proprietors, but from choice. His farms were mostly in Scotland, and he believed he was the first to build a silo in that country. His experience had been varied, probably because he had lacked that knowledge of chemistry and other sciences, but still the advantages he had derived from it had exceeded his original expectations. He was every year proceeding with his experiments on a larger scale, and with greater success. He was, unfortunately, not a member of the Commission now sitting under the chairmanship of Lord Walsingham, but he was sure a better appointment than that of Lord Walsingham to the chairmanship of that committee could not have been made. He had studied the subject practically, and it was on his estates in Norfolk that the first conclusive proofs of this system had been realised—more especially with reference to sheep-farming. This was a process which was absolutely in its infancy, and they were on the threshold, he hoped, of great results, but it was only by practical experiments, carried on by gentlemen who had means and inclination, aided by scientific men, that these results could be obtained. Mr. Jenkins had pointed out, very properly, that two of the greatest advantages of ensilage were, first, that you could make it in a wet season, when you could not make hay; and secondly, that you could make it whether it rained or not, and preserve its nutritive qualities for use in the lambing or calving season, when it was most required. He was bound to say he thought the chemistry of this subject took precedence of the mechanical side, and though Mr. Harris rather complained that so little had been said about the mechanical part, he must remember that it was

brought forward that evening simply as a chemical subject. Some other time they might have an opportunity of discussing it from a mechanical point of view; the chemical question, however, was the most important. They had to consider, by means of chemistry, what they wanted; but the science of mechanics was so far advanced, that when once they knew what they wanted there would be no difficulty in obtaining it. One point to which he personally had directed special attention in Scotland, was making ensilage of heather for sheep-feeding purposes. He believed this was a new subject, but he had mentioned it to some friends, and had tried experiments himself in this direction, which had been completely successful. They all knew that sheep, when they wandered over the heather hills in summer and autumn, throve very well—better, perhaps, than when fed on grass, and continued to do so until the snow came and covered the heather, so that they could not get at it, when it became necessary to hand-feed these large flocks of sheep, or to remove them to southern pasturages, or feed them with hay or turnips, which might, perhaps, be more judiciously used for cattle. He had in summer cut the heather and preserved it in stacks, and found, if this was done at the proper season, before the frost set in and killed the juices, the sheep would eat it in the same manner as they ate hay. If this proved to be the fact to the fullest extent, he believed it would produce a revolution in sheep-farming, and would enable the country to feed more than double the quantity of sheep it could at present. He hoped some of the gentlemen present would look into the matter, and join him in his experiments, and he should be very glad if they would communicate the results to him.

Mr. Lloyd, in reply, said Mr. Harris had pointed out three very valuable facts in connection with ensilage, the principal one being that the crops could be saved at the best moment. He also mentioned that he had found scouring result from its use, and he was not alone in that experience. Others had done the same, but he had not yet been able to find out why. Professor Kinch had confirmed his results in the main. If Mr. Jenkins's idea were carried out, that nothing should be published until after ten years' experience, he feared he would be one of the first to complain of chemists that they were backward in tackling this question. They must do the best they could, and to complain of them for not being able to master one of the most difficult problems which had ever come before the agricultural chemist, was rather throwing cold water on the endeavours of those who were trying to overcome these difficulties. Dr. John Voelcker said he had not thrown any fresh light on the subject. If so, he could only say that he had a knowledge of facts which he had not seen published, because there were one or two points which he believed important, and which were certainly new. He had shown that there was, alongside the action of organised ferments, a chemical action, by pointing out first the influence of water on the albumen; and in discovering the presence of peptones he had gone a step beyond any chemist up to the present time. It was that which suggested to him whether the changes which were taking place in the silo were similar to the changes taking place in the animal body, and so far as he could judge by the work he had done—he did not come to speak of what others had done—the changes in the nitrogenous compounds were identical with those which took place in the process of digestion. Physiologists had been working at this question for a great number of years, and yet they could not tell where the link was between the peptone and the urea. He would not say he was certain he found urea, for it was not an easy thing in silage to isolate; but he thought urea would be found, and that would complete the change of decomposition of albumenoids similar to the methods going on in the animal body; the ammonia would of course be the next substance formed, and that had been shown to be present. With regard to starch going back to sugar, upon which Mr. Cross also made some remarks, and he had a very large experience, which enabled him to speak with authority on this question of the uncertainty of starch in plants; if they thoroughly realised what the plant was doing, they would remember that starch was merely the medium by which the carbonic acid of the atmosphere was converted into sugar to build up the plant. Therefore starch would never be found as a permanent thing in the growing portion of the plant. That accounted for Mr. Cross's difficulty, seeing it was only transferring substances, but when you got to the seed, there it was fixed permanently, and it was put into the silo in the fixed form as starch. With regard to the equations, which Dr. Voelcker found fault with as not expressing all that went on, he could only say that he did not know more than the whole chemical world. If he could explain the infinite variety of changes which took place in the conversion of one substance into another in a plant, he should have more knowledge than was possessed by those who had studied the subject for a much longer time than he had. But if Dr. Voelcker would carefully study the works of Pasteur, he would find they threw a great deal of light on the question. In answer to Mr. Howard, he would say that he did not think it possible that any commercial value could be put on any constituents of food relative to one another; it would be a question of the relative proportion of nitrogenous compounds which were assimilable by the animal. As far as the nitrogenous constituents were concerned, they could give the relative value of one food to another, but, with regard to the carbo-hydrates, the isolation of these, and the definite statement in what form they existed, was a question of such immense difficulty, that it was practically impossible. He hoped Mr. Howard would bring forward the results of his experiments on temperatures; but the great difficulty was, if you

commenced with a silo full to the height of 12 feet, and took the temperature for every foot downwards, the next time you took the temperature the mass had consolidated, perhaps, into 8 feet, and how could you say where the consolidation had taken place, or fix the points at which you had taken the temperatures before? He commenced his studies on this subject with the belief that the chemical changes were really greater than the physiological, but the more he studied the more he found he was wrong, and that the chemical changes were altogether subsidiary to the physiological changes produced by ferments. With regard to the calculation of the analyses, to take the mineral matter as a basis was totally erroneous, and it appeared to him that that arose in this way, that the mineral matter put into the silo was not due to the mineral matter of the plant, but that that which adhered to it, and was extraneous altogether, outweighted the mineral matter natural to the plant. He had endeavoured to get nearer to the estimation of this question by getting rid of the carbonic acid and silicate, but any one who would take several samples of silage from the same layer would find the variations of mineral matter so great, that he would distrust any calculations based upon them. Such calculations had given such extraordinary, and what common sense would call ridiculous, results. Neither would anything be gained by calculating the analyses to the same amount of dry weight. You could not compare a grass crop with clover, or with maize; you must compare clover with clover, grass with grass, and maize with maize, if you wanted to arrive at any real results. He knew Mr. Cross would complain of his method of stating the results, but until he would give a more accurate determination of the digestibility and the indigestibility of the constituents of cellulose, they must go on under the old method of considering whether the substances were soluble in acid and alkali. This was the simple attempt chemists made to represent the action of the stomach, and the alkalinity of the intestines, and until they could find a more complete method of realising what the animal could do, he did not think they were far wrong in taking that as a basis. He believed Mr. Christy was right in saying that the temperature, if first obtained at the bottom, would tend to drive off an amount of moisture from the layer above it, which would tend to make sweet silage, even although it contained a little more than 75° of moisture. The fact that Mr. Fry himself did not always obtain sweet silage from one soil, but sweet and sour from the same, and from the same crop, showed that it was very difficult to hit exactly on the per-centage of moisture which would give sweet silage. Lastly, he would say that the great difficulty was to commence the analysis soon enough after the substance was taken out of the silo to prevent change having taken place, and if Dr. Voelcker wished to base any statements on analyses, he must commence his work down at Woburn, and not wait until the substance had come to London, because it would not be the silage which was taken out of the silo. The moment it was taken out, that moment it began to change. In the laboratory, he found changes going on so rapidly, that they were absolutely astounding, so much so, that he found a substance which, when he commenced analysing it, had been exceedingly acid, had undergone fermentation, which rendered it extremely alkaline. The changes taking place were so difficult to realise, that many years of work, analytical, physiological, and practical, were required. All he had ventured to do was to lay before the meeting those facts which he considered were, if not proved, somewhat certain, as the result of his own experiments.

The CHAIRMAN then proposed a vote of thanks to Mr. Lloyd, which was carried unanimously.

FOREIGN & COLONIAL SECTION.

Tuesday, April 28, 1885; the Right Hon. W. E. FORSTER, M.P., in the chair.

The paper read was "The Federation of the Empire," by J. E. GORST, Q.C., M.P.

The paper and discussion will be printed in the next number of the *Journal*.

NINETEENTH ORDINARY MEETING.

Wednesday, April 29th, 1885; WILLIAM WOODALL, M.P., in the chair.

The following candidates were proposed for election as members of the Society:—

Cohn, Maurice, 24, Lancaster-road, Belsize-park, N.W., and 27, Throgmorton-street, E.C.
Few, Rev. Charles E., The Rectory, Seal, near Sevenoaks, Kent.
Jehangeer, Jehangeer Cowasjee, 14, Kensington-park-gardens, W.

The following candidates were balloted for and duly elected members of the Society:—

Clere, Frederick de Jersey, Wanganui, New Zealand.
Dawson, William, Chingford-hall, Leyton, Essex.
Doxsey, Rev. Isaac, 186, The Grove, Camberwell, S.E.
Fulton, Henry B., 42, Claverton-street, Pimlico, S.W.
Pass, Alfred C., Rushmere-house, Durdham-down, Bristol.
Peyton, Ernest Phelps, Chemical Works, Lister-street, Birmingham.
Polglase, Francis James Wicks, Tyne Vale Chemica Works, Forth-bank, Newcastle-on-Tyne.
Proctor, John, 5, St. George's-ter., Queen's-gate, S.W.
Stern, Edward D., 11, Prince's-gate, S.W.

Whitehead, Smith Taylor, 21, Upper Phillimore-gardens, W.
Wood, Thomas William, 3, Royal-crescent, Notting-hill, W.

The paper read was—

RESEARCHES ON SILK FIBRE.

By Thomas Wardle, F.C.S., F.G.S.

The Chamber of Commerce of Lyons having done me the honour to request me to conduct an examination of the fibres of the various species and varieties of silk, both those obtained from domesticated worms, and wild or semi-wild ones, on the basis of my former researches, partly described in my "Handbook of the Wild Silks of India," I have, for the past twelve months, given a more thorough examination of these fibres, from cocoons in my own possession, as well as from cocoons furnished to me by the Lyons Chamber, and Monsieur Rondot, an influential member of the chamber, and ex-president of the silk section of the International Exhibition of Paris, 1878, whose able time and energies are given to the nurture and development of the French silk industry. The President of this important and influential Chamber, has in several letters to me expressed his high opinion of the value and importance of these continued investigations, the consequence of which is that, at Lyons, a laboratory is being constructed, called Laboratoire de Sericiculture, and an earnest sericiculturist, Monsieur Dusuzeau, has been appointed curator, whose office and work it will be to record the results of examination of the various races of silk, methodically and regularly.

The effect of this annual and scientific work on the silk fibre will be to give, by a closer insight and more extended knowledge, a direction in the better reeling and sizing of silk, both European and Eastern, in the earlier stages of manufacture. The production of a thread of raw silk as regular and uniform as possible is still a desideratum, particularly in China, where the raws have mostly become very irregular and badly sized, probably through price, competition, and decrease of sufficiently skilled reeling labour. In India, too, there is great need of improvement and renewed stimulus in this respect; for although much was done years ago to improve the reeling of Bengal silks, the effort has not been continuous enough. Much remains to be done, for I think if India silk could be well reeled generally, it is from that continent we ought to look for a great supply. In the wild silks of India, it is simply the coming want, and the application of improved reeling appliances will mark a new era in the utilisation of Tussur and several other species of wild silks, a utilisation which is already one of the most remarkable facts in sericiculture, and which may be said to take its date practically in 1878, when the amelioration and capabilities of these wild silks were first announced and shown by me in the Indian Section of the Paris Exhibition of that year, under the direct supervision of H.R.H. the Prince of Wales and of the energetic efforts of Sir Philip Cunliffe-Owen, with such success as gained from the jury the highest award—the diploma of honour for the Viceroy of India.

It might be naturally enough supposed that in a continuous thread or bave of silk, as unwound from the cocoon, an absolute regularity of fibre would not be found; such is, indeed, the case, and my investigations have had for their objects the recording of these differences throughout the entire length of the cocoon thread, both as to diameter or thickness of fibre, strength, and tension, or elasticity of various species of silk, including the silk of commerce, produced by the *Bombyx mori*, or mulberry-fed worm, also various wild silks, and some spider silks. These points have been recorded at intervals of fifty metres, and the following tables show the results.

All species of silkworms have two stores of silk, one on each side of the alimentary canal; and below their mouths they have two so-called spinnarets or orifices, to which I have ventured to give the name of "seripositors," through which the silk issues simultaneously in pairs of fine parallel filaments or fibres, forming in fact a double thread. For all practical purposes I have considered it sufficient, in estimating the tensions, strengths, and diameters, to give those of this double thread; as in reeling the silk from the cocoons into skeins, it is, of course, invariably drawn off in the form of a double thread, although so fine is it as to be apparently one.

The French term for this double thread is "*bave*;" and each of the single fibres composing it is called "*brin*," which is synonymous with our word "fibre."

The method by which I have reeled the bave or double thread from the cocoons is as follows:—The cocoons were first softened by keeping them immersed for several hours in a

dilute aqueous solution of Marseilles soap, which, before it was used, was examined and found to be free from any appreciable excess of alkali, and then raising the temperature of this liquid for a few minutes to about 120° F. When the cocoons were soft enough, the short or waste fibres were pulled off the outside of them until the end of the double reelable thread or bave was found. This was attached to the machine, a drawing of which is on the table, and the thread reeled, the cocoon remaining floating on the surface of the soap solution in which it was softened until nothing was left, except an unwindable and extremely thin shell of silk immediately surrounding the chrysalis. The machine also registers the length of bave reeled.

I have preferred to examine and to register the two fibres composing the bave conjointly because—

1st. I thus get all the results which would be obtained by examining them singly, as whether the tension is estimated with either a single or a double thread, the same mean or average must be obtained, and by finding the average strength and diameter of the double fibre, and dividing these by two, the average strength and diameter of the single fibre can be, of course, easily ascertained.

2nd. I find it somewhat difficult and very tedious to separate the two threads by any convenient solution, and I think there is risk of mechanical injury to the fibres, which would seriously affect the results.

In estimating the tension of the bave, I cannot distinguish that one fibre breaks before the other, but both appear to break at the same time, although the fibres of several species of wild silks being almost flat and joined together in pairs by their edges are not so strongly united as, and separate more easily than, the round fibres of mulberry silk; and in estimating the tension of the bave of these silks, it must of course be first ascertained that the two fibres have not become separated.

After each cocoon was reeled into a skein, I began to unwind the double thread from the machine, commencing at the inner end, that is, the end that was nearest the chrysalis, taking the first five metres for examination. I then unwound fifty metres, which I threw away, and took the next five metres for examination; and I went on thus until I arrived within five metres of the other or outer end of the reeled thread, which five metres I always examined, although the length of bave between this and the preceding five metres examined might be less than fifty metres. The bave, or double thread, of each cocoon was therefore tested for its strength, tension, and diameter, at every fifty metres of its length, except at its outer end.

Silk is well known to possess considerable elasticity. I have endeavoured to estimate this elasticity or tension by attaching three decimetres of the bave at a fixed point, on a scale divided into centimetres and millimetres, and then stretching it until it broke, and noting the point on the scale at which the breakage occurred.

The strength of the bave was ascertained by a serimeter, contrived in a homely manner, consisting of a spring balance with a scale divided into drams and eighths of drams avoirdupois. Fifteen centimetres of the bave were attached to the balance arm and gradually pulled until breakage occurred, the point of its occurrence remaining registered on the scale of the balance.

The diameter of the bave was measured under the microscope with a power of 250 diameters, with the aid of an eyepiece micrometer, seven of the divisions on which represented $\frac{1}{1000}$ inch.

Between thirty and forty cocoons of different kinds formed the subject of this examination. Amongst the mulberry silks are several breeds or "races" from the various silkworm districts of the South of France, several from Japanese and Chinese seed but reared in France and Switzerland, also Italian and Grecian, as well as cocoons from Japan and China. The list also includes the following wild silks:—The Indian *Tussur*, the Chinese *Pernyi*, the Japanese *Yamamai*, as well as *Muga* silk, *Attacus cynthia*, and *Attacus ricini* and *Lasiocampa otus*. Their peculiarities, structure, and properties are fully described in the tables which follow.

Next in order is arranged a very interesting series of spider silks of the following species.

1. An Epeirid, *Nephylengis malabarensis* (Watch), an Indian spider sent to me for examination by Professor Thiselton Dyer.

The following five have been sent to me by the eminent authority on spiders, the Rev. O. P. Cambridge, of Bloxworth Rectory, Wareham:—

2. *Nephila plumipes* (Koch), United States, America.

3. Egg cocoons of an Epeirida sp. Adelsburg.

4. Silk from the nest of *Uroctea durandii* (Walck), from Palestine.

5. Egg cocoons of *Meta menardi* (Latr.) Devonshire.

6. Egg cocoons of *Voconia maculata* (Kays), N. Corrientes, La plata.

7. A supposed spider silk, dyed red in South America, lately sent to me for examination by Messrs. Marshall and French, of London.

1. *Three Pale Yellow Cocoons, race Bione (Drôme) Nyons.*

Not very readily reelable, and a rather large quantity of waste on the surface of the cocoon. Internal unreelable shell surrounding the chrysalis extremely slight and transparent. The silk on the outside of the cocoon is almost white, but becomes gradually yellow as the interior of the cocoon is approached. The most internal part of the reelable fibre is quite bright yellow. Length of cocoon before reeling $1\frac{1}{8}$ inches. Diameter, $\frac{3}{4}$ inch. Length of double fibre reeled, 265 metres.

The averages of six estimations of the tension of the bave, at each distance tried, throughout the cocoon were as follows:—The figures represent the number of centimetres which three decimetres of the double fibre will stretch or extend before it breaks.

Inner end.	At 55 metres.	At 110 metres.
3·2	3·7	3·3
At 165 metres.	At 220 metres.	Outside end.
4·2	3·4	4·7

The averages of six estimations of the strength of the bave or double thread at each distance tried, throughout the cocoon, were as follows:—The figures represent the number of drams avoirdupois which fifteen centimetres of the double fibre will support before breaking.

Inner end.	At 55 metres.	At 110 metres.
$3\frac{7}{8}$	$4\frac{4}{8}$	$5\frac{3}{8}$
At 165 metres.	At 220 metres.	Outside end.
4	$4\frac{3}{8}$	$4\frac{7}{8}$

The averages of six estimations of the diameter of the bave or double thread, at each distance tried throughout the cocoon were as follows:—The figures represent the diameter in fractions of an inch.

Inner end.	At 55 metres.	At 110 metres.
$\frac{1}{810}$	$\frac{1}{790}$	$\frac{1}{775}$
At 165 metres.	At 220 metres.	Outside end.
$\frac{1}{900}$	$\frac{1}{890}$	$\frac{1}{920}$

2. *White Cocoon, race Japan; Grisons Suisse; harvest of* 1884.

This cocoon reeled tolerably well, but had on its surface a rather large amount of was e unreelable fibres. The internal unreelable shell of silk surrounding the chrysalis was moderately thin. Length of cocoon before reeling, $1\frac{1}{8}$ inches; width, 5 inches. The length of the double fibre reeled was 270 metres.

Tension.

Inner end.	55 metres.	110 metres.
3·7	4	4·7
165 metres.	220 metres.	Outer end
5·0	4·9	4·6

Strength.

Inner end.	55 metres.	110 metres.	165 metres.
$8\frac{2}{8}$	8	$7\frac{2}{8}$	$8\frac{2}{8}$
	220 metres.	Outside end.	
	$6\frac{1}{8}$	$4\frac{1}{8}$	

Diameter.

Inner end.	55 metres.		
$\frac{1}{660}$	$\frac{1}{700}$		
110 metres.	165 metres.	220 metres.	Outside end.
$\frac{1}{700}$	$\frac{1}{740}$	$\frac{1}{740}$	$\frac{1}{930}$

3. *White Cocoon from Kalamata, Morea, Greece; crop of* 1884.

This cocoon reeled tolerably well, having on its surface a moderate amount of waste unreelable fibres. The internal unreelable shell of silk surrounding the chrysalis was moderatly thin. The silk throughout the cocoon was white, like China silk. Length of cocoon before reeling, $1\frac{1}{8}$ inches; width, $\frac{5}{8}$ inches. The length of the double fibre reeled was 360 metres.

Tension.

Inner end.	55 metres.	110 metres.
3·2	3·4	3·1
165 metres.	Outside end.	
3·5	4·1	

Strength.

Inner end.	55 metres.	110 metres.
5	$5\frac{2}{8}$	$6\frac{1}{8}$
165 metres.	Outside end.	
$6\frac{4}{8}$	5	

Diameter.

Inner end.	55 metres.	110 metres.
$\frac{1}{770}$	$\frac{1}{660}$	$\frac{1}{630}$
165 metres.	Outside end.	
$\frac{1}{630}$	$\frac{1}{770}$	

4. *Green Cocoon, from Japan; Grisons, Suisse; crop of* 1884.

This cocoon reeled tolerably well, having on its surface a moderate amount of waste unreelable fibres. The internal unreelable shell of silk surrounding the chrysalis, was about the usual thickness of that of mulberry silk cocoons. Length of cocoon before reeling, $1\frac{1}{8}$ inches; width, $\frac{5}{8}$ inch. The length of the double fibre reeled was 320 metres.

Tension.

Inner end.	55 metres.	110 metres.	165 metres.
3·5	3·4	3·5	2·7

220 metres.	275 metres.	Outside end.
2·9	3·1	3·1

Strength.

Inner end.	55 metres.	110 metres.	165 metres.
$4\frac{4}{8}$	$6\frac{5}{8}$	$5\frac{5}{8}$	$6\frac{3}{8}$

220 metres.	275 metres.	Outside end.
6	$5\frac{5}{8}$	$6\frac{2}{8}$

Diameter.

Inner end.	55 metres.	110 metres.	165 metres.
$\frac{1}{770}$	$\frac{1}{740}$	$\frac{1}{740}$	$\frac{1}{720}$

220 metres.	275 metres.	Outside end.
$\frac{1}{740}$	$\frac{1}{770}$	$\frac{1}{870}$

5. *Cocoon of Mulberry Silk, China.*

This cocoon reeled very easily, having on its surface only a moderate amount of waste unreelable fibres. The external uureelable shell of silk surrounding the chrysalis was very thin and transparent. The silk throughout the cocoon was very white. Length of the cocoon before reeling, $\frac{7}{8}$ inch. Width $\frac{1}{2}$ inch. Length of double fibre reeled, 476 metres.

Tension.

Inner end.	55 metres.	110 metres.	165 metres.
2·8	3·7	3·8	3·8

220 metres.	275 metres.	330 metres.
4·3	4·2	4·8

385 metres.	440 metres.	Outside end.
4·3	3·6	3·2

Strength.

Inner end.	55 metres.	160 metres.	165 metres.
$2\frac{3}{8}$	$3\frac{4}{8}$	$3\frac{6}{8}$	$3\frac{5}{8}$

220 metres.	275 metres.	330 metres.
$4\frac{4}{8}$	$4\frac{6}{8}$	$5\frac{3}{8}$

385 metres.	440 metres.	Outside end.
$4\frac{2}{8}$	4	$3\frac{2}{8}$

Diameter.

Inner end.	55 metres.	110 metres.	165 metres.
$\frac{1}{1000}$	$\frac{1}{950}$	$\frac{1}{900}$	$\frac{1}{875}$

220 metres.	275 metres.	330 metres.
$\frac{1}{820}$	$\frac{1}{20}$	$\frac{1}{700}$

385 metres.	440 metres.	Outside end.
$\frac{1}{800}$	$\frac{1}{850}$	$\frac{1}{960}$

6. *White cocoon from Bagdad, Turkey in Asia.*

Reeled tolerably well, having on surface a moderate amount of waste unreelable fibres. Internal unreelable shell of silk surrounding the chrysalis about the usual thickness of that of the mulberry silk cocoon. Length of cocoon before reeling, about $1\frac{5}{8}$ inches. Width, $\frac{5}{8}$ inches. Length of double fibre reeled, about 540 metres.

Tension.

Inner end.	55 metres.	110 metres.	165 metres.
3·7	4·6	4	4·4

220 metres.	275 metres.	330 metres.	385 metres.
4·1	3·1	4·4	3·7

440 metres.	495 metres.	Outside end.
4·4	3·8	2·5

Strength.

Inner end.	55 metres.	110 metres.	165 metres.
$4\frac{4}{8}$	$6\frac{7}{8}$	$8\frac{6}{8}$	8

220 metres.	275 metres.	330 metres.	385 metres.
$7\frac{3}{8}$	$8\frac{1}{8}$	$7\frac{4}{8}$	8

440 metres.	495 metres.	Outside end.
8	7	$6\frac{7}{8}$

Diameter.

Inner end.	55 metres.	110 metres.	165 metres.
$\frac{1}{930}$	$\frac{1}{665}$	$\frac{1}{665}$	$\frac{1}{735}$

220 metres.	275 metres.	330 metres.	375 metres.
$\frac{1}{665}$	$\frac{1}{605}$	$\frac{1}{605}$	$\frac{1}{700}$

440 metres.	495 metres.	Outside end.
$\frac{1}{665}$	$\frac{1}{735}$	$\frac{1}{825}$

7. *Yellow cocoon from Ronda, Province of Granada, Spain.*

Reeled tolerably well, having on surface a moderate amount of waste unreelable fibres. Internal unreelable shell of silk surrounding the chrysalis about the usual thickness of that of mulberry silk cocoons. Length of cocoon, before reeling, about $1\frac{1}{2}$ inches. Width, $\frac{11}{16}$ inch. Length of double fibre reeled, about 335 metres.

Tension.

Inner end.	55 metres.	110 metres.	165 metres
2·0	2·7	2·6	3·6

220 metres.	275 metres.	330 metres.
2 9	4·0	4·2

Strength.

Inner end.	55 metres.	110 metres.	165 metres.
$2\frac{6}{8}$	$3\frac{4}{8}$	$6\frac{6}{8}$	$7\frac{3}{8}$

220 metres.	275 metres.	Outside end.
$7\frac{3}{8}$	$8\frac{4}{8}$	$6\frac{4}{8}$

Diameter.

Inner end.	55 metres.	110 metres.	165 metres.
$\frac{1}{1030}$	$\frac{1}{775}$	$\frac{1}{775}$	$\frac{1}{700}$

220 metres.	275 metres.	Outside end.
$\frac{1}{605}$	$\frac{1}{775}$	$\frac{1}{700}$

8. *White cocoons from Granada, Spain.*

Reeled very well, having on surface a moderate amount of waste or unreelable fibres, and the internal unreelable shell surrounding the chrysalis about the usual thickness of that of the mulberry silk cocoon. Length of cocoon before reeling, $1\frac{1}{2}$ inches. Width, $\frac{7}{8}$ inch. Length of double fibre reeled, 375 metres.

Tension.

Inner end.	55 metres.	110 metres.	165 metres.
3·8	2·4	2·9	3·4
220 metres.	**275 metres.**	**330 metres.**	**Outside end.**
4·3	4·4	4·4	4·4

Strength.

Inner end.	55 metres.	110 metres.	165 metres.
$4\frac{4}{8}$	$8\frac{1}{8}$	$8\frac{4}{8}$	6
220 metres.	**275 metres.**	**350 metres.**	**Outside end.**
6	6	$8\frac{3}{8}$	$9\frac{3}{8}$

Diameter.

Inner end.	55 metres.	110 metres.	185 metres.
$\frac{1}{635}$	$\frac{1}{635}$	$\frac{1}{700}$	$\frac{1}{775}$
220 metres.	**275 metres.**	**330 metres.**	**Outside end.**
$\frac{1}{825}$	$\frac{1}{825}$	$\frac{1}{700}$	$\frac{1}{660}$

9. *White cocoon of Italian grown Novi.*

Reeled exceedingly well, having on surface a tolerable amount of waste unreelable fibres. Internal unreelable shell of silk surrounding the chrysalis about the usual thickness of that of the mulberry silk cocoons. Length of cocoon before reeling about $1\frac{1}{16}$ inches. Width $\frac{3}{4}$ inch. Length of double fibre reeled, about 620 metres.

Tension.

Inner end.	55 metres.	110 metres.	165 metres.
3·3	3·6	3·2	4·6
220 metres.	**275 metres.**	**330 metres.**	**375 metres.**
4·9	4·9	3·5	4·8
440 metres.	**495 metres.**	**550 metres.**	**Outside end.**
3·5	2·7	3·6	2·6

Strength.

Inner end.	55 metres.	110 metres.	165 metres.
$3\frac{1}{8}$	$4\frac{7}{8}$	$5\frac{5}{8}$	$6\frac{1}{8}$
220 metres.	**275 metres.**	**330 metres.**	**385 metres.**
$7\frac{2}{8}$	$7\frac{7}{8}$	$8\frac{7}{8}$	$7\frac{3}{8}$
440 metres.	**495 metres.**	**580 metres.**	**Outside end.**
$6\frac{7}{8}$	$8\frac{6}{8}$	$7\frac{5}{8}$	$5\frac{5}{8}$

Diameter.

Inner end.	55 metres.	110 metres.	165 metres.
$\frac{1}{1075}$	$\frac{1}{1000}$	$\frac{1}{875}$	$\frac{1}{665}$
220 metres.	**275 metres.**	**330 metres.**	**385 metres.**
$\frac{1}{700}$	$\frac{1}{875}$	$\frac{1}{825}$	$\frac{1}{735}$
440 metres.	**495 metres.**	**550 metres.**	**Outside end.**
$\frac{1}{635}$	$\frac{1}{825}$	$\frac{1}{635}$	$\frac{1}{535}$

10. *White bivoltine cocoons from Japan, bred at Montpellier.*

Easily windable, but a rather large quantity of waste on the surface of cocoons. Internal unreelable shell surrounding chrysalis extremely slight and transparent. Silk throughout cocoon very white. Length of cocoon before reeling $1\frac{1}{8}$ inches, and diameter $\frac{1}{2}$ inch Length of double fibre reeled 316 metres.

Tension.

Inner end.	55 metres.	110 metres.	165 metres.
5·5	6·4	6·5	6·5

220 metres.	275 metres.	Outside end.
7·4	6·9	5·4

Strength.

Inner end.	55 metres.	110 metres.	165 metres.
$2\frac{6}{8}$	4	$4\frac{6}{8}$	$5\frac{2}{8}$

220 metres.	275 metres.	Outside end.
$5\frac{3}{4}$	6	4

Diameter.

Inner end.	55 metres.	110 metres.	165 metres.
$\frac{1}{880}$	$\frac{1}{775}$	$\frac{1}{750}$	$\frac{1}{790}$

225 metres.	275 metres.	Outside end.
$\frac{1}{730}$	$\frac{1}{725}$	$\frac{1}{775}$

11. *White Cocoons from Corea, Greece, bred at Montpellier.*

Reeled exceedingly well, having on surface only a very slight amount of waste or unreelable fibres, and the internal unreelable shell surrounding the chrysalis being extremely slight and transparent. Silk throughout the cocoon very white. Silky walls of cocoon considerably thicker than usual, as shown by the greater length of fibre reeled, as well as by section. Length of cocoon before reel-

ing, 1 inch; width, $\frac{5}{8}$ inch. Length of double fibre reeled, 479 metres.

Tension.

Inner end.	55 metres.	110 metres.	165 metres.
1·6	3·2	2·7	1·7
230 metres.	275 metres.	230 metres.	385 metres.
2·6	4·4	4·8	3·2
440 metres.	Outside end.		
4·6	4·1		

Strength.

Inner end.	55 metres.	110 metres.	165 metres.
$3\frac{2}{8}$	$5\frac{1}{8}$	$5\frac{1}{8}$	$5\frac{1}{8}$
220 metres.	275 metres.	330 metres.	
$5\frac{1}{8}$	6	$6\frac{1}{8}$	
385 metres.	440 metres.	Outside end.	
$6\frac{3}{8}$	6	3	

Diameter.

Inner end.	55 metres.	110 metres.	165 metres.
$\frac{1}{710}$	$\frac{1}{710}$	$\frac{1}{710}$	$\frac{1}{710}$
220 metres.	275 metres.	350 metres.	
$\frac{1}{710}$	$\frac{1}{710}$	$\frac{1}{720}$	
385 metres.	440 metres.	Outside end.	
$\frac{1}{730}$	$\frac{1}{750}$	$\frac{1}{705}$	

12. *Yellow cocoon of a bivoltine race, from Tonkin.*

Reeled well. Had on surface a moderate amount of waste unreelable fibres; and the internal unreelable shell surrounding the chrysalis about the usual thickness of the mulberry silk cocoons. Length of cocoon before reeling, about $1\frac{7}{16}$ inches. Width, $\frac{9}{16}$ inch. Length of double fibre reeled, about 200 metres.

Tension.

Inner end.	55 metres.	110 metres.
2·6	6·3	6·6
165 metres.	Outside end.	
5·6	4·9	

Strength.

Inner end.	55 metres.	110 metres.
$3\frac{2}{8}$	$5\frac{7}{8}$	$6\frac{3}{8}$
165 metres.	Outside end.	
$5\frac{7}{8}$	$5\frac{6}{8}$	

Diameter.

Inner end.	55 metres.	110 metres.
$\frac{1}{875}$	$\frac{1}{775}$	$\frac{1}{875}$
165 metres.	Outside end.	
$\frac{1}{875}$	$\frac{1}{665}$	

13. *Pale yellow cocoon, from Morestel, France.*

Reeled tolerably well, having on surface a moderate amount of waste unreelable fibres. Internal unreelable shell of silk surrounding the chrysalis about the usual thickness of that of the mulberry silk cocoon. Length of cocoon, before reeling, $1\frac{7}{16}$ inch. Width, $\frac{11}{16}$ inch. Length of double fibre reeled, about 425 metres.

Tension.

Inner end.	55 metres.	110 metres.
3·4	3·3	4·6
165 metres.	220 metres.	275 metres.
2·8	2·9	3·5
330 metres.	385 metres.	Outside end.
4·9	3·5	4·6

Strength.

Inner end.	55 metres.	110 metres.
$5\frac{1}{8}$	$7\frac{7}{8}$	9
165 metres.	220 metres.	275 metres.
$6\frac{3}{8}$	$9\frac{1}{8}$	$9\frac{3}{8}$
330 metres.	385 metres.	Outside end.
$9\frac{5}{8}$	$10\frac{4}{8}$	$8\frac{2}{8}$

Diameter.

Inner end.	55 metres.	110 metres.
$\frac{1}{735}$	$\frac{1}{700}$	$\frac{1}{665}$
165 metres.	220 metres.	275 metres.
$\frac{1}{875}$	$\frac{1}{665}$	$\frac{1}{665}$
330 metres.	385 metres.	Outside end.
$\frac{1}{665}$	$\frac{1}{580}$	$\frac{1}{930}$

14. *White cocoon of a species from Shanghai, China, bred at Monplaisir, Lyons.*

Reeled exceedingly well, having on its surface only a very slight amount of waste or unreelable fibres, and the internal unreelable shell surrounding the chrysalis being extremely slight and transparent. Silk throughout the cocoon very white. Length of cocoon before reeling 1 inch, and diameter about $\frac{5}{8}$ inch. Length of the double fibre reeled, 308 metres.

Tension.

Inner end.	55 metres.	110 metres,	165 metres.
4·4	5·0	2·7	5·9
220 metres.	275 metres.	Outside end.	
6·0	5·7	5·2	

Strength.

Inner end.	55 metres.	110 metres.	165 metres.
$4\frac{7}{8}$	$6\frac{6}{8}$	$2\frac{4}{8}$	$6\frac{6}{8}$
220 metres.	275 metres.	Outside end	
$6\frac{4}{8}$	$6\frac{4}{8}$	$7\frac{5}{8}$	

Diameter.

Inner end.	55 metres.	110 metres.
$\frac{1}{870}$	$\frac{1}{870}$	$\frac{1}{870}$

165 metres.	220 metres.	275 metres.	Outside end.
$\frac{1}{780}$	$\frac{1}{870}$	$\frac{1}{890}$	$\frac{1}{920}$

15. *White Cocoon from Vallerangue (Gard), France.*

Reeled exceedingly well, having on its surface only a very slight amount of waste or unreelable fibres, and the internal unreelable shell surrounding the chrysalis being extremely slight and transparent. The cocoon, before reeling, 1⅜ inches, and diameter ¾ inch. Length of the double fibre reeled, 640 metres.

Tension.

Inner end.	55 metres.	110 metres.	165 metres.
5	5·6	5·3	4·3
220 metres.	**275 metres.**	**330 metres.**	**385 metres.**
5	5·9	5·6	6·2

440 metres.	495 metres.	550 metres.
5·6	6·2	5·9

605 metres.	Outside end.
3·5	4·5

Strength.

Inner end.	55 metres.	110 metres.	165 metres.
3	$3\frac{7}{8}$	$3\frac{5}{8}$	$4\frac{2}{8}$

220 metres.	275 metres.	330 metres.
$4\frac{6}{8}$	$5\frac{1}{8}$	$5\frac{7}{8}$
385 metres.	**440 metres.**	**495 metres.**
$6\frac{2}{8}$	$6\frac{4}{8}$	6
550 metres.	**605 metres.**	**Outside end.**
$5\frac{5}{8}$	$4\frac{4}{8}$	$3\frac{6}{8}$

Diameter.

Inner end.	55 metres.	110 metres.	165 metres.
$\frac{1}{875}$	$\frac{1}{885}$	$\frac{1}{905}$	$\frac{1}{830}$

220 metres.	275 metres.	330 metres.
$\frac{1}{800}$	$\frac{1}{775}$	$\frac{1}{720}$
385 metres.	**440 metres.**	**495 metres.**
$\frac{1}{750}$	$\frac{1}{810}$	$\frac{1}{840}$
550 metres.	**605 metres.**	**Outside end.**
$\frac{1}{850}$	$\frac{1}{890}$	$\frac{1}{960}$

16. *Cocoon from Fluang Chioo ts'an silkworm, China; race, domestic and bivoltine.*

The fibres of this cocoon are very regular in diameter, the bave being $\frac{1}{1175}$ inch, and the single fibre $\frac{1}{1750}$ inch. The silk is light yellow throughout the cocoon.

17. *Pai jsi ts'an. White cocoon, China; race, domestic.*

The bave of this cocoon has an average diameter of $\frac{1}{825}$ inch, and the single fibre $\frac{1}{1650}$ inch. The diameter varies only within narrow limits throughout the bave.

18. *White Cocoon; race, Sina, bred at Nyons (Drôme).*

The bave of this cocoon has an average diameter of $\frac{1}{715}$ inch, and the single fibre $\frac{1}{1430}$ inch. The diameter varies only within narrow limits throughout the bave.

Wild Silk.

19. *Cocoon of Tussur Silk (Antheræa mylitta), written also Tasar, Tussore, Tussah, Tusser, from Cuttack.*

This cocoon reeled moderately well, but had on its surface a somewhat considerable amount of waste or unreelable fibres, but the internal unreelable shell surrounding the chrysalis was thin and transparent. Silk throughout the cocoon of the usual fawn colour of Tussur silk. Length of cocoon (without pedicle) before reeling, 1¼ inches. Width, ¾ inches. Length of double fibre reeled, 426 metres.

Tension.

Inner end.	55 metres.	110 metres.
3·3	3·6	4·3
165 metres.	**220 metres.**	**275 metres.**
3·3	4·7	5·2
330 metres.	**385 metres.**	**Outside end.**
6·4	6·8	4·7

Strength.

Inner end.	55 metres.	110 metres.
$12\frac{5}{8}$	12	12
165 metres.	**220 metres.**	**275 metres.**
$13\frac{5}{8}$	13_{8}	$11\frac{2}{8}$
330 metres.	**385 metres.**	**Outside end.**
$15\frac{5}{8}$	$14\frac{3}{8}$	$13\frac{2}{8}$

Diameter.

Inner end.	55 metres.	110 metres.
$\frac{1}{305}$	$\frac{1}{305}$	$\frac{1}{300}$
165 metres.	**220 metres.**	**275 metres.**
$\frac{1}{300}$	$\frac{1}{290}$	$\frac{1}{295}$
330 metres.	**385 metres.**	**Outside end.**
$\frac{1}{300}$	$\frac{1}{305}$	$\frac{1}{310}$

20. *Cocoon of Antheræa Pernyi, China, the so-called Tussur silk of China.*

This cocoon reeled tolerably well, having on its surface a moderate amount of waste un-

reelable fibres. The internal unreelable shell of silk surrounding the chrysalis was moderately thin. The silk throughout the cocoon was of the usual fawn colour of Tussur and most of the other Indian wild silks. Length of the cocoon before reeling, $1\frac{5}{8}$ inches. Width, $\frac{3}{4}$ inch. Length of double fibre reeled, 492 metres.

Tension.

Inner end.	55 metres.	110 metres.	165 metres.
3·6	4·5	6·2	6·7
220 metres.	275 metres.	330 metres.	385 metres.
6·7	6·4	6·4	5·5
	440 metres.	Outside end.	
	5·1	5·0	

Strength.

Inner end.	55 metres.	110 metres.	165 metres.
$5\frac{6}{8}$	$6\frac{1}{8}$	$8\frac{7}{8}$	$10\frac{5}{8}$
220 metres.	275 metres.	330 metres	385 metres.
11	$11\frac{7}{8}$	$11\frac{2}{8}$	$7\frac{6}{8}$
	440 metres.	outside end.	
	7	$6\frac{7}{8}$	

Diameter.

Inner end.	55 metres.	110 metres.	165 metres.
$\frac{1}{390}$	$\frac{1}{380}$	$\frac{1}{370}$	$\frac{1}{370}$
220 metres.	275 metres.	330 metres.	385 metres.
$\frac{1}{360}$	$\frac{1}{360}$	$\frac{1}{370}$	$\frac{1}{370}$
	440 metres.	Outside end.	
	$\frac{1}{380}$	$\frac{1}{380}$	

21. *Cocoon of Attacus Ricini, or Eria Silkworm.*

This cocoon was extremely difficult to reel, and had on its surface a considerable amount of waste unreelable fibres. The internal unreelable shell of silk surrounding the chrysalis was moderately thin. The silk throughout the cocoon was white, some cocoons being rust colour. Length of the cocoon before reeling, $1\frac{1}{2}$ inches. Width, $\frac{5}{8}$ inch. Length of double fibre reeled, 320 metres.

Tension.

Inner end.	55 metres.	110 metres.	
3·5	4·4	5·1	
165 metres.	220 metres.	275 metres.	Outside end.
5·1	4·5	4·3	4·2

Strength.

Inner end.	55 metres.	110 metres.	165 metres.
$3\frac{2}{8}$	$4\frac{2}{8}$	$5\frac{7}{8}$	6
220 metres.	275 metres.	Outside end.	
$5\frac{1}{8}$	$3\frac{7}{8}$	$2\frac{7}{8}$	

Diameter.

Inner end.	55 metres.	110 metres.	165 metres.
$\frac{1}{585}$	$\frac{1}{550}$	$\frac{1}{560}$	$\frac{1}{535}$
220 metres.	275 metres.	Outside end.	
$\frac{1}{500}$	$\frac{1}{580}$	$\frac{1}{585}$	

22. *Cocoon of Antheræa Assama, or Muga Silkworm.*

This cocoon reeled tolerably well, having on its surface a moderate amount of waste unreelable fibre. The internal unreeable shell of silk surrounding the chrysalis was moderately thin. The silk throughout the cocoon was the usual fawn colour of Tussur and other wild silks of India. Length of the cocoon before reeling, $1\frac{3}{4}$ inches. Width, $\frac{7}{8}$ inch. Length of double fibre reeled, 370 metres.

Tension.

Inner end.	55 metres.	110 metres.	165 metres.
5·7	7·3	5·8	7·1
220 metres.	275 metres.	330 metres.	Outside end.
6·9	6·7	5·8	6·0

Strength.

Inner end.	55 metres.	110 metres,	165 metres.
$5\frac{5}{8}$	$9\frac{6}{8}$	$9\frac{1}{8}$	$7\frac{1}{8}$
220 metres.	275 metres.	330 metres.	Outside end.
$7\frac{3}{8}$	$7\frac{3}{8}$	$5\frac{6}{8}$	$5\frac{7}{8}$

Diameter.

Inner end.	55 metres.	110 metres.	165 metres.
$\frac{1}{390}$	$\frac{1}{370}$	$\frac{1}{385}$	$\frac{1}{390}$
220 metres.	275 metres.	330 metres.	Outside end.
$\frac{1}{390}$	$\frac{1}{400}$	$\frac{1}{400}$	$\frac{1}{390}$

23. *Cocoon of Antheræa Yama-mai, Japan.*

This cocoon reeled tolerably well, and had on its surface only a moderate amount of waste unreelable fibres. The internal unreelable shell of silk surrounding the chrysalis was thin and transparent. The silk throughout the cocoon is very beautiful and lustrous, being of a light yellowish green colour, whilst the superficial layer of the cocoon is bright green. Length of the cocoon before reeling, $1\frac{3}{4}$ inches. Width, 1 inch. Length of double fibre reeled, 480 metres.

Tension.

Inner end.	55 metres.	110 metres.	165 metres.
4·6	5·0	8·1	10·0
220 metres.	275 metres.	330 metres.	385 metres.
10·1	9·9	8·0	6·4
	440 metres.	Outside end	
	5·4	4·9	

Strength.

Inner end.	55 metres.	110 metres.	165 metres.
$13\frac{6}{8}$	$14\frac{4}{8}$	$13\frac{6}{8}$	$14\frac{4}{8}$
220 metres.	275 metres.	330 metres.	385 metres.
15	14	14	14
	440 metres.	Outside end.	
	13	$13\frac{4}{8}$	

Diameter.

Inner end.	55 metres.	110 metres.	165 metres.
$\frac{1}{585}$	$\frac{1}{565}$	$\frac{1}{565}$	$\frac{1}{520}$
220 metres.	275 metres.	330 metres.	385 metres.
$\frac{1}{555}$	$\frac{1}{530}$	$\frac{1}{535}$	$\frac{1}{565}$
	440 meters.	Outside end.	
	$\frac{1}{560}$	$\frac{1}{565}$	

24. *Cocoon of Attacus Cynthia, Algeria.*

This cocoon was rather difficult to reel, and had on its surface a somewhat considerable amount of waste or unreelable fibres, and the internal unreelable shell of silk surrounding the chrysalis was not so thin as in the Tussur cocoon. Silk throughout the cocoon of the usual fawn colour of Tussur and other wild silks. Length of cocoon before reeling, 2 inches. Width at widest part, $\frac{1}{2}$ inch. Length of double fibre reeled, 260 metres.

Tension.

Inner end.	55 metres.	110 metres.	165 metres.
4·3	5·1	6·1	7·2
	220 metres.	Outside end.	
	6·7	6·6	

Strength.

Inner end.	55 metres.	110 metres.	165 metres.
$5\frac{1}{8}$	7	$4\frac{6}{8}$	$5\frac{3}{8}$
	220 metres.	Outside end.	
	$4\frac{7}{8}$	$4\frac{6}{8}$	

Diameter.

Inner end.	55 metres.	110 metres.	165 metres.
$\frac{1}{565}$	$\frac{1}{516}$	$\frac{1}{600}$	$\frac{1}{590}$
	220 metres.	Outside end.	
	$\frac{1}{580}$	$\frac{1}{600}$	

25. *Cocoon of Antheræa Frithii.*

This cocoon being pierced by the exit of the moth could not be properly reeled, but I have determined the tension, strength, and diameter of the fibres in two different parts of the cocoon, with the following results:—

Tension.

Inner end.	Outside end.
7·4	8·8

Strength.

Inner end.	Outside end.
19	$9\frac{4}{8}$

Diameter.

Inner end.	Outside end.
$\frac{1}{358}$	$\frac{1}{368}$

In this cocoon, the two fibres of which the bave is composed had a great tendency to separate, and did not adhere together as in mulberry silk cocoons.

26. *Bourre, or waste silk, from two reticulated cocoons of Caligula Japonica. One red, the other, light grey.*

These fibres run in pairs. They are flat and united together by their edges. They are not marked with longitudinal striæ like Tussur silk fibres. They have an exceptionally large diameter, the red one measuring $\frac{1}{330}$-inch for its single fibre, and $\frac{1}{165}$-inch for its bave, and the other light grey one $\frac{1}{310}$-inch for its single fibre, and $\frac{1}{155}$-inch for its bave. These figures show the average diameters, the variations not being unusually great.

27. *Cocoons of Sai yen ts'an; from a new kind of wild silkworm feeding on the mulberry leaf.*

The fibres of these extremely small cocoons are round, run in pairs to form the bave, and have all the essential characters of mulberry silk. They are, however, much finer than the fibres of the silks of commerce, the diameter of the bave being $\frac{1}{1100}$ inch, and of the single fibre $\frac{1}{2800}$ inch. This diameter is very uniform throughout the cocoons. The colour of the cocoons and silk is very little different from that of Tussur.

28. *Lasiocampa otus;* 1 *cocoon.*

This cocoon was so very much damaged when I received it, that it was impossible to reel it. I have measured the diameter of a few fibres taken from it at random, with the following results. The figures represent the diameters in fractions of an inch:—

$\frac{1}{2000}$	$\frac{1}{2000}$	$\frac{1}{2000}$	$\frac{1}{2000}$	$\frac{1}{2800}$	$\frac{1}{2800}$

Average of single fibre, $\frac{1}{2150}$; double, $\frac{1}{1075}$.

The fibres were all white, and the cocoon measured in length $2\frac{7}{8}$ inches, and in width $1\frac{3}{8}$ inches.

Before proceeding with the spider silk, it will be well to mention the outcome of these examinations.

First, as to the tension. It is clearly proved that the tension varies in proportion to the strength and thickness of the bave; being less at the thinner ends of the bave than at the thicker middle portions. In the *Bombyx mori* silks (the mulberry-fed worm silks), the difference in tension between the thinnest parts and the thickest is, in many cases, 1·0 to 2·0 centimetres, and often more, in three decimetres of the bave, that is, a metre of the thinnest parts of the bave would stretch, say, 12·0 centimetres, whilst at the thickest parts it could be extended 15·0 to 18·0 centimetres, or more, before breaking; and the same proportion between tension and thickness obtains throughout the varying tension of the whole of the bave of each cocoon.

The strength, as might be expected, varies in the same proportion as the tension, the thinnest parts of the bave, roughly speaking, breaking with a weight of 3 to 5 drams, and the thickest parts, with a weight of 5 to 8 drams.

Coming to the most important feature of the bave, it will be interesting to show in which way the thread varies in size or thickness, or, as I have previously termed it, diameter. The transverse section of the thinnest parts of the bave (the double thread be it remembered), again speaking roughly, measures $\frac{1}{900}$ inch to $\frac{1}{1000}$ inch, whilst at the thickest parts its measurement is $\frac{1}{700}$ inch to $\frac{1}{800}$ inch. The six or eight trials along the entire length of the cocoon thread as a general rule show a gradually increasing thickness from each end of the cocoon towards the middle, where it is thickest, in some instances by as much as a third. I consider the exceptions to be accidental and in no way invalidating the theory and discovered fact.

In the diameter of the bave, it is noticeable, that towards each end of it the disproportion in diameter of the two fibres composing it becomes gradually greater, so that often at the beginning or end of the cocoon one fibre or brin is much thicker than the others.

Now, it will be asked, what is the practical outcome of all this? First, a silken thread or fabric is best when equally strong and also when equally thick or equally thin. As it is always the practice in reeling cocoons to reel, say, four or more cocoon threads together, it is manifestly impossible to reel an even filature or thread of raw silk if the cocoons are all commenced at the same time or if cocoons are taken varying much in the sizes of their threads. This investigation tends to instruct those engaged in reeling the cocoons by clearly showing where the inequalities are, and at the same time to guide them in greater niceties of manipulation so as to secure as even and perfect a result as possible.

Where the bave differs so much in thickness as one-third, it is impossible to expect an even thread to be constructed by rule of thumb, and I am glad to say that the Chamber of Commerce at Lyons places very high value on these examinations.

Greater attention is paid to this already in Italy, France and Broussa, than perhaps, elsewhere; although much of the Japanese silk is excellently reeled. I have here a sample of Bengal silk, which has been lent to me by a Leek manufacturer of sewing silks, which he states is so beautifully reeled as to produce silk thread for the sewing-machine, of perfect regularity and strength; but for some time great complaints have been rife as to the unequal reeling, and consequently unequal sizing of China silks. It is impossible to construct delicate fabrics in the loom, where evenness is required, unless the silk is well sized.

The same may be said to a certain extent of the wild silks, but there are somewhat greater irregularities throughout the length of the cocoon in these silks than in the domesticated breeds. In Eria silk, the thickening of the fibres towards the centre of the cocoon is particularly noticeable, in Tussur silk, less so; but as only one cocoon has been examined, I do not insist that this exception is constant.

There is no doubt that it is not difficult now to reel Tussur silk into very regular even threads. In 1876 I went to Italy, at the instance of the Government of India, to see if it were possible to make a good thread out of Tussur cocoons. I was perfectly successful, and the results may be seen at the India Section of the South Kensington Museum, and will be found amply described in my "Handbook of the Wild Silks of India." Since that time a number of collaborateurs in India and China have been confirming these results. One gentleman in India, who has availed himself of the best European reeling appliances, has for some time regularly sent me samples of raw silk of his reeling, which have gradually become more and more satisfactory. He now writes saying that there is nothing left to be desired, except to wait for more skill on the part of his young silk-workers; his observation is fully borne out in the opinions of several English silk manufacturers to whom I have submitted his results.

The characteristic glittering appearance of Tussur silk when dyed, especially in black, is most probably owing to the fibres being flattish, and the bave becoming separated into its ultimate fibres more easily than in mulberry silks, thus giving play to greater reflection of light.

Owing to the extreme difficulty of obtaining transverse sections of the fibre of silk sufficiently thin, I have not yet been able to complete my investigations on its absolute structure, either in the undyed or dyed state. I am at present engaged on this, and hope before long to be able to describe the appearances, under the highest powers, of sections which must be as thin as, at least, $\frac{1}{4000}$-inch, in order that they may lie flat on the side. The importance of this inquiry will be understood, when I state that to such an extent has the falsification of silk arrived by weighting with chemical matter, that in many fabrics the bulk is increased to as much as eight times the original bulk of the fibre. It will also be useful if we can get at a clearer idea as to how tinctorial matter, with and without mordants, permeates or penetrates the silk fibre, as well as to the action of certain matters with which silk has a peculiar affinity, as, for example, tannic acid, salts of tin, iron, chromium, &c.

Spider-silk.

I come now to a short consideration of spider-silk. As is so well known, spiders are great producers of this fibre, both for their webs and nests.

As the examination of spider-silk is comparatively new to me, I have not had time to make a very minute investigation of it, but it will form the basis of future interesting work.

Professor Thiselton Dyer, some time ago, was good enough to ask me to investigate some spider-silk which a correspondent, Mr. Duthie, had sent to him from India, and in describing this I think I cannot do better than read first the letter which Professor Dyer received from Mr. Duthie. The letter is dated, "Botanical Gardens, Saharunpur, November 25th, 1884," and is as follows:—

"By to-day's mail I am sending you some queer-looking stuff—spider-silk. It was extremely lovely as I saw it when coming down from Almora the other day. Enormous webs of it stretched between the trees and shrubs overhanging the lake at Bhim Tál, in Kuman. I saw a notice a short time ago, in some paper, regarding the use which might be made of these string-webs. A particular kind, of a golden yellow colour, occurring in New Zealand, was specially recommended, and in fact it had been manipulated with success as a substitute for silk. What I saw at Bhim Tál answers very much to the description of the New Zealand kind, and if a supply is wanted for an experiment on a large scale, it could easily be obtained from this locality, after the rainy season is over. In a small tin-box enclosed in the packet I am now sending are a few of the spiders, not in very good order, but I had to send for them."

Professor Dyer called in the learned aid of the Rev. O. P. Cambridge, of Bloxworth Rectory, Wareham, relative to the natural history part of the subject, and, as his letter is very interesting, I do not think it will be considered out of place here. He says:—

"The spiders are broken, shrivelled, and crushed out of all recognition almost. The genus, however, is clear enough, and I have no hesitation in pronouncing them to be (an Epeïrid) *Nephilengys malabarensis*, Walck. Walckenaer described it as an Epeira. I described it also some years ago from the China Sea and the Congo, and other parts of the West African coast (supposing it to be new), as *Nephila rivulata*. Subsequently, L. Koch separated it from *Nephila*, under its present (good) generic name *Nephilengys*. It seems to be almost cosmopolitan; it has been described under another name, from Amboina, by Doleschall, and under another, again, by L. Koch as well as twice, under different names, by Walckenaer. I have it from the China seas and India, as well as from Australia, Borneo, and West Africa, and I think (though I cannot at this moment refer to my collection and books) from other regions as well. It appears to be exceedingly abundant in all its localities. The silk (which is new to me) is very strong and tough, and I should imagine that the fabric which might be made from it would be almost imperishable. Whether it could be spun out from silk collected *en masse* from the spiders' snares, I should doubt. I fancy the only way to get the silk in condition for spinning and weaving, would be after some such method as Dr. B. G. Wilder proposed, and experimented upon (I believe) successfully, some years ago, in North America. But the great drawback will always remain, that spiders devour each other, and so cannot be fed, or their silk obtained, without great trouble and cost."

After carefully examining this spider-silk, I made the following report:—

"The fibre is evidently of a silken nature, and, like silk, it is loaded with a gummy substance. In a boiling soap solution this gum, or varnish, dissolves, leaving the fibre apparently pure, and of the nature of fibröin, if not identical with it.

"Eight micrometric measurements of the diameter

of the fibre in different parts of the mass showed great irregularity in diameter ($\frac{1}{2300}$, $\frac{1}{2800}$, $\frac{1}{3500}$, $\frac{1}{2800}$, $\frac{1}{3500}$, $\frac{1}{3500}$, $\frac{1}{3500}$, $\frac{1}{3500}$), giving an average of $\frac{1}{3100}$ inch. It is, therefore, a considerably finer fibre "or brin" than silk, the brin of Italian silk being not finer than $\frac{1}{2100}$ inch.

"The average strength of the spider-silk is proportionately greater than that of silk, a single fibre of the spider-silk breaking with an average weight of $2\frac{1}{2}$ drams avordupois, whilst that of China silk, so much thicker, breaks at 2 to 3 drams.

"The most curious property of this fibre is its elasticity, which is considerably greater than that of silk; 30 centimetres of it will stretch to an average length of 36·6 centimetres before breaking, whilst China silk will only stretch to 34 or 35 centimetres.

"Like silk, this spiders' web-silk is lustrous, and has a round fibre.

"Its coating of gum or varnish is disproportionate to the weight of the silk. On boiling with soap it lost weight at the rate of $7\frac{3}{4}$ ozs. per lb. avordupois, that is, 1 lb. of the spider-silk discharged $7\frac{3}{4}$ ozs. of gum. In the silk of the *Bombyx mori* worm the proportion is much less, the gum seldom being over 25 to 30 per cent. of the total weight. Before boiling in soap, the spider-silk was well combed to remove all the dirt possible, but a little remained.

"The fibre appears to receive tinctorial matter readily. I enclose a small pattern of it dyed, and also one as I received it, and one after boiling in soap.

"I believe, if it can be obtained in quantity, it might be packed in bales and sent to England, where it would readily find a market for being carded and spun into spun silk threads for sewing or weaving purposes.

"It is difficult to estimate its marketable value. I dare say it would at any rate realise 1s. to 2s. per lb. It is rather dirty, and this would to some extent detract from its value as compared with silk waste.

"I have tried to discover how many seripositors this spider has, but beyond noticing, under the microscope, that the fibres often run in pairs, but not regularly, I am unable to trace whether there are two, as in the ordinary silkworms, or more. Probably an examination of the spider would show this, or of an undisturbed portion of its secreted silk."

Mr. Cambridge has been kind enough to send me five other species of spider-silks. I have not been able to do more than to examine the diameters of their fibres, which are as follows:—

	Diameters of ultimate fibres.
Egg cocoons of an *Epeïrida sp.*	$\frac{1}{7000}$-inch.
Egg cocoons of *Meta menardi*, Latr. Devonshire	$\frac{1}{4000}$-inch.
Nest of *Uroctea Durandii*, Walck, Palestine	$\frac{1}{8000}$-inch.
Silk of *Nephila plumipes*, Koch, United States, America	$\frac{1}{2150}$-inch.
Egg cocoons of *Voconia maculata*, Kays, N. Corrientes, La Plata	$\frac{1}{14000}$-inch.

The small specimens of spider-silks are on the table, and, along with that of the *Nephila plumipes*, is a small portion of ribbon made with its silk for the warp, and with a cotton weft.

There does not seem to be much prospect of any successful reeling of any of the species of spider-silk, but it is quite within the limits of possibility that they may be produced in such quantity as to be useful for being carded and spun, and if so, there will no doubt be a considerable utilisation of them.

Short of a thorough analysis of the spider-silks, which I have not yet had opportunities of making, it seems to possess, to all appearance, all the physical properties of mulberry silk. It certainly has a central axis of silky matter, probably fibröin, and also an external coating of "gum," or "grès," or varnish, like silk, probably to protect it from the action of the weather.

Dr. Bowman, in his first lecture on "The Structure of the Wool Fibre," at the Bradford Society of Dyers and Colourists, on January 22nd, 1885, states that silk fibre consists of three parts—a central silk cylinder forming the principal part of the fibre, outside this, a layer of albumen, and on the surface of this, a thin coat of gelatine. I have not been able to confirm this, and cannot go beyond my observations, which at present limit my conclusions to there being only a central substance of fibröin, coated with what is technically termed in England "gum," and in France "grès," the gum constituting from 25 to 30 per cent. of the original weight of the silk, and being entirely removable, by the necessary operation before dyeing, of boiling the silk in a solution of soap.

In the case of the mulberry silks, the fibres seem structureless, having the appearance of a glass rod, and, like glass, have a more or less conchoidal fracture when broken. Wild silks differ from this in structure very much. In almost all of them, each fibre seems to consist of minute fibrets, and under the microscope appear numbers of thin, longitudinal striations throughout the length of the fibre. In the case of Tussur silk, I have been able to separate these fibrets, as you will presently notice on the screen.

I ought here to mention two properties of

silk which have to do somewhat with structure and practical manipulations.

First, silk is more or less affected by water, and always holds it in what Dr. Bowman calls a state of water of hydration, containing more in damp weather and less in dry weather. At the Lyons conditioning-house, silks sent to be conditioned are made absolutely dry at a high temperature in suitably constructed vessels. They are then weighed, and 11 per cent. is added to the dried weight for water of hydration or natural moisture. During the last twenty years I have made an enormous number of trials of this hygrometric property of silk, and I have found that when silk, having been divested of its natural gum and dried at a temperature not exceeding 150° Fahr., is exposed to the air, it gains in weight from 5 to 10 drams per boiled-off-silk-lb., or from 2 to 4 per cent. This shows also that a much higher temperature is required to drive off all the water of hydration.

Second, the electric properties of silk are remarkable. Silk is a most perfect non-conductor of electricity when dry, and it is amusing to see how loose dry silk fibres start up in *cheveux de frise* fashion when excited by friction. This property seriously interferes with the manipulation of silk in various stages of its manufacture when it becomes too dry. In some manipulations it has to be kept moist by artificially applied means, such as glycerine, &c. It will be seen from this how much more suitable our colder and moister English climate is for silk manufacture than hotter and drier ones.

With regard to the chemical composition of silk, there is a little perplexity. Probably the most satisfactory examination yet made, is the following, by Mr. Schorlemmer :—

"When raw silk is heated in water under pressure, it yields two compounds.

"Fibröin, $C_{15}H_{23}N_5O_6$, constitutes about 66 per cent. of raw silk; it is a silky, glistening substance, which is insoluble in water, but dissolves in strong acids, alkalies, and a solution of cuprammonium sulphate. When boiled with dilute sulphuric acid, it yields glycocoll, leucine and tyrosine.

"Sericin, or silk-gelatin, $C_{15}H_{25}N_5O_8$, is a substance resembling gelatin. Its hot aqueous solution is precipitated by alcohol, and after drying, the precipitate forms a colourless powder, which in cold water swells up to a gelatinous mass. On boiling it with dilute sulphuric acid, it yields a small quantity of leucine, and larger quantities of tyrosine and serine, or amidoglyceric acid."

Dr. Bowman, in his most excellent lectures on wool fibre, gives some interesting facts, in his third paper on wool fibre, from which I will quote, and it will be interesting also to give the composition of cotton and wool fibres for comparison.

Perfectly pure cotton is identical with pure cellulose, which is represented by the formula given in the following table, where the formula for silk is contrasted with those for wool and cotton :—

Cotton....................	$C_6 H_{10} O_5$
Silk	$C_{24} H_{38} N_8 O_8$
Wool	$C_{42} H_{157} SO_{15}$

The important additional element of nitrogen in silk and wool will be observed, as well as wool standing alone in containing sulphur.

I hardly think that this is the right way of stating the formulæ for silk. I am inclined to doubt their accuracy, for it is not quite clear that silk is purely an organic substance. If pure silk is fibröin, its formula would be as stated by Mr. Schorlemmer, $C_{15}H_{23}N_5O_6$; but if the composition to be described is that of the fibröin, sericin, albumen and gelatin contained in silk as it exudes from the silkworm, it can hardly be formulated as a distinct chemical compound.

I may here state, in passing, that Dr. Wanklyn's admirable ammonia process for estimating the amount of organic matter in water, is applicable for determining the exact amount of silk when in combination with weighting matter. I am at present at work on this, and as soon as the results are worked out, I intend that they shall form the substance of another paper in connection with details concerning the *modus operandi* of silk weighting, now so very largely practised on the Continent of Europe, and to a certain but more limited extent, I am sorry to say, in England, where in recent degenerate days foreign competition in price has rendered it more or less imperative. It will be of the highest importance to describe a method by which chemists can at once, with certainty, determine the exact amount of sophistication in any so-called silk fabric.

Is not the time arrived when the British consumer should know by the compulsory declaration of the amount of weight or adulteration what he is really buying? I think so.

I also give from Dr. Bowman's lecture the composition of wool, and also of horny tissue, which it resembles very closely :—

Average Composition of Horny Tissue, according to Mulder.

	Per cent.
Carbon	50·54
Hydrogen	6·91
Nitrogen	16·83
Oxygen	22·07
Sulphur	3·65
	100·00

Composition of Wool.

	Scherer.	Mulder.
Carbon	50·65	50·5
Hydrogen	7·03	6·8
Nitrogen	17·71	16·8
Oxygen	24·61	20·5
Sulphur	0·00	5·4
	10·000	100·0

Dr. Bowman found that, after drying a number of samples of wool at about 100° F., and then exposing them to the air in an ordinary warehouse unheated in any way but with a temperature of about 50° F. to 60° F., there was an average gain of 8·28 per cent. of moisture, which he terms the water of hydration. He also says:—

"That on the Continent there are official and public testing establishments in many of the large manufacturing centres, both in France and Germany, where reports can be obtained in regard to the condition both of wool tops and yarn, and that it has been found, by a number of experiments conducted in these places, that if wool is subjected to the highest temperature which it can sustain without scorching, it will regain from 18 to 18½ per cent. of moisture, and that we may, therefore, regard this as its normal condition under the usual atmospheric conditions.

"The above analyses are analyses of the residual or pure wool after the fat, sweaty matter and yolk or suint have been removed by treatment with hydrochloric acid, anhydrous ether, cold water, and alcohol in succession, and then again exhausted with alcohol and ether. The quantity of these foreign substances amounts to from 20 to 50 per cent. in air-dried wool."*

The following Table will show the position in the animal kingdom of the silkworms and spiders which have produced the silk described in this paper:—

DIVISION III.—ARTICULATA.

SUBDIVISION II.—Anthropoda (or true articulata).

Class, Insecta.
Sub-Class, Metabola.
Order, Lepidoptera.
Sub-Order, Heterocera.
Group, Bombycina.

Family, Bombycidæ.
Genus, Bombyx.
Species, *Bombyx mori.*

Family, Saturnidæ.

Genus, Attacus.
Species, *A. cynthia.*
A. ricini.

Genus, Antheræa.
Species, *A. mylitta.*
A. yamamai.
A. Assama.
A. pernyi.

Genus, Caligula.
Species, *C. Japonica.*

Class, Arachnida.
Order,
Family, Epeiridæ.
Group, Orbitelariæ, or Geometric Web-weavers.
Nephilengys malabarensis.
Meta menardi, Latr.
Nephila plumipes, Koch.
Epeïrida sp., Adels.
Family, Urocteoidæ.
Group, Tubitalariæ, or Tubular Nest-spinners.
Uroctea Durandïi, Walck.
Family, Thomisidæ.
Group, Laterigradæ, or laterally extended-legs spiders.
Voconia maculata, Kays.

* Dr. Bowman's Lectures on Wool Fibre at the Bradford Society of Dyers and Colourists, April, 1885.

Commercial Aspects of the Silk Industry.

The necessity for the minutest inquiry into every detail concerning the economy and excellence of manufacturing silk, cannot be overestimated. The fact of the Lyons Chamber of Commerce, at this late period of the history of so successful a silk industry as theirs, commencing to build a laboratory for more minute investigation, proves it.

Our attention is almost compulsorily arrested by the fact of the decadence of this industry in our own country, a decadence threatened by extinction, gradual but sure.

A few useful figures from the Board of Trade returns of the value of the imports into the United Kingdom, and of the exports of British and Irish produce from 1854 to 1880, ordered by the House of Commons to be printed in 1882, most seriously shows this. I will only give the totals of various kinds of silk goods manufactured by countries in Europe during two decades, and purchased by England.

Imports of Silk Manufactures from the Continent of Europe, Decade 1854 to 1863.

	£
Broad stuffs, silk and satin	13,679,321
Broad stuffs, velvet......	1,382,870
Ribbons of silk and satin and other kinds	14,175,544
Plush for making hats	1,023,748
Other kinds of unenumerated manufacture, all silk, and silk mixed with other materials	3,470,852
Total..........	33,732,335

Decade 1874 to 1883.

	£
Broad stuffs, silk and satin	63,868,365
*Broad stuffs, velvet..............	8,456,076
Ribbons of silk, satin, and other kinds	18,919,378
Plush for making hats	237,193
Other kinds of unenumerated manufactures of all silk, and silk mixed with other materials	26,829,560
Total..........	118,310,572

In 1855, our total imports of manufactured silk from countries in Europe amounted to a value of £1,826,525.

In 1880, the total imports of manufactured silk from countries in Europe had grown gradually year by year in value to £13,085,083.

* The velvets for 1883 are included with broad stuffs of silk and satin.

Thus in 25 years we had come to buy from countries in Europe of articles we ought to have manufactured for ourselves no less than £11,258,558, an almost incredible sum.

Did we *lose* this industry, or was it only a surplus to our then established silk industry? The distressed state to-day of Coventry, Congleton, Macclesfield, Spitalfields, and the Manchester silk districts, answers this question too painfully. The trade is gone practically, and gone from us to more skilled and persevering centres abroad, and gone, too, from our own country, which possesses the most suitable climate in the world for the silk manufacturing operations of winding, throwing, dyeing, warping, and weaving.

The valuable reports of the Royal Commission on Technical Instruction, of which Commission my friend, Mr. Woodall, M.P., who has done me the honour to preside this evening, is a most hard-working member, not only fully shows how large an industry there is abroad, but insists that it is only by equal technical skill and increased art knowledge that our old silk trade can be re-won.

The breeding of silkworms has for a long time been a most important industry in Italy and the south of France. The total production of cocoons from these worms in Italy amounted, in 1881, to 39,300 tons, and in 1880, to 40,930 tons. In France, in 1881, the production of cocoons amounted to 20,362,179 = 9,090 tons, and were principally raised in the Departments Gard, Ardèche, Drome, Vaucluse, Var, and by the mouths of the Rhone. French statistics show that from this large quantity of French cocoons was produced, in 1881:—

	Raw silk. lbs.		tons.
France	1,650,000	or	737
In Italy	6,523,000	,,	2,912
Corsica and Algeria	6,182	,,	3
Austrian Hungary	324,632	,,	145
Spain and Portugal	184,800	,,	82
Total product in West Europe .	8,688,614	,,	3,879
From the Levant:—			
Turkey:—			
Anatolia	158,400	,,	71
Salonica, Volo, Adrianople ..	264,000	,,	118
Syria	365,200	,,	163
Greece	28,600	,,	13
Persia and Georgia	550,000	,,	246
	1,366,200	,,	611

It will be seen from these figures what a very important matter it is that the greatest atten-

tion should be paid to the earlier operations in the manufacture of silk threads, and one cannot be surprised at the Lyons Chamber of Commerce starting anew to ascertain all the facts relative to the proper sizing, *i.e.*, producing even threads of silk in a more minute and exact manner than heretofore. For if the earlier stages and operations have not for their aim and effect the production of an even thread, no after manipulation of winding, warping, dyeing, weaving, or finishing can effectually avail in turning out fabrics of the finest qualities, in all or any of the various purposes for which silk is used. Hitherto the sizing has been by rule of thumb, and dependent on skilled eyesight and fingers, in first sorting cocoons and afterwards reeling 4, 6, 8, or more together, according to the required thickness of thread, or what at this stage is termed raw silk, that is, the state in which it comes into the market before it is manufactured into organzine, tram singles, &c. An examination of the thickness of the ultimate fibre must then take first place, and this method has now commenced, and will be carried on in the new Lyons Laboratory, not only of all species and varieties, or, as the French call them, races, of cocoons, but of the thickness of these fibres throughout the entire length of the cocoons, which I have discovered to be very variable. Next come the important examinations of strength and tension, or elasticity, which the foregoing Tables illustrate in both the silks of domesticated and of wild worms.

The necessity for examinations such as these is more apparent in the manufacture of those silks which, some years ago, I ventured to designate by the name wild. For some of the wild silks of India, for example, there is a great future, a prediction warranted by the successful employment of the principal wild silk, Tussur—or as it is termed in its vernacular, Tasar—during the last seven years. It would not be right to omit here the mention of the name of Sir George Birdwood, C.S.I., M.D., in connection with Tussur silk.

In my South Kensington Museum "Handbook of the Wild Silks of India," I quoted a paper which he wrote in India, as long since as 1859, in which he advocates the desirability of an attempt being made in England to utilise Tussur silk, a suggestion which he has lived to see now abundantly realised.

The extent to which the consumption of Tussur silk in Europe has reached is very large. France imported, from one port alone, last year, 8,000 bales of raw Tussur silk. Several English manufacturers have thrown during last year large quantities as high, in one instance, as 1,000 bales. The whole of these recently-increased imports may be said to be badly reeled from the cocoon, much of it very badly reeled indeed, causing the European manufacturers to cry out loudly for improved reeling in the Eastern centres of production. Already has the improvement begun, and to such an extent has it been proved practicable by one of my many correspondents and collaborateurs in the East, that raw Tussur is produced from a single bave only—that is, so delicate in the improved reeling, that the beautiful raw Tussur you see here is simply the double fibre from a single cocoon reeled into a single thread successfully, proving conclusively enough that in this, as in other species of silk, if the quality of the raw silk put in the market is defective in any way, it is not the fault of the silkworm, which always does its work with the precision that the honey bee builds her cell, but rather the hitherto inadequency of perception of man to ascertain and adjust the natural variations and differences of the fibre of so wondrous a beauty, and so incomprehensible a product.

If this contribution to a more exact understanding of silk fibre shall serve in however small a degree to stimulate any persons in the direction towards the recovery of our almost lost industry, my object and aim will be fully served.

My acknowledgements are due to my assistants, Mr. T. Rigby, and to my son Bernard, for their care and help in the examinations of silk fibre for this paper.

I am indebted to Messrs. Bullock and Sons, silk merchants, of London and Macclesfield, for the various specimens of raw silk lent for exhibition.

LIST OF SPECIMENS EXHIBITED.

Yellow Bengal raw silk. Number of cocoons reeled together, 7 to 11; beautifully reeled silk and of splendid quality. Present market value in London, 11s. per lb.

White Japan raw silk, very even and well reeled. Number of cocoons reeled together, 6 to 8.

China raw silk, white, well reeled. Number of cocoons reeled together, 8 to 12. Present market value in London, 14s. per lb.

Taysaam raw silk, dirty white, very badly reeled indeed. Number of cocoons reeled together very

various, from 21 to 100. Present market value in London, 5s. per lb.

China organzine, fairly good quality. Present market value in London and the provinces, 17s. 6d. per lb.

China tram, of fairly good quality. Present market value in London and the provinces, 17s. per lb.

Italian raw silk, yellow and white, excellent quality. Present market value in London, 18s. per lb. Number of cocoons reeled together, 6 to 8.

Brutia raw silk, white. Present market value in London, 19s. per lb. Number of cocoons reeled together, 6 to 8.

(These prices are interesting as illustrations of the depression in the European silk trade, and consequent low prices, probably the lowest on record in modern times.)

Two specimens of damask weaving in patterns and colours. Leek made silks. Well reeled silks.

Specimen of printed satin in colours on a pattern woven ground. Leek made and printed silk. Well reeled silk.

Indian woven Corah silk printed by myself. The weaving of this silk is irregular, owing to being woven of imperfectly reeled raw silk.

Tussur undyed silk cloth, woven in India, of very imperfectly reeled Tussur raw silk.

A specimen of the same, printed in two colours by myself.

Hearthrug of Tussur silk plush, thick and deep pile, in various colours patterned. Lent by Wardle and Co., 71, New Bond-street.

Case of spider silks, as described in the paper. Tubular and other nests.

Two mulberry silkworm moths, *Bombyx mori*, and their cocoons.

Male and female specimens of the Leek Moorland Emperor moths, *Saturnia carpini*, and their cocoons (male and female). This species feeds on the heather, and spins its cocoons also in the heather.

Male and female specimens of the large Egger moth, *Bombyx Quercus*, with cocoons containing male and female chrysalis, found in the heather in the moorlands near Leek.

List of Lantern-slides Illustrating this Paper, all enlarged from microscopical slides.

1. Cotton, showing its flat and twisted fibre of celulose.

2. Flax.—The elementary fibres of flax (*Linium usitatissimum*) are cells of pullucid membranes, joined end to end with cane-like joints, between which form thickened vessels with fibrous matter; along with these are seen the woody fibre or tissue, consisting of "elongated cells or tubes, with tapering extremities which overlap each other, and by their union longitudinally form the fibres called hemp and flax."*

3. Typical woollen fibre.

4. Coarse Lincoln wool.

5. China wool, showing the imbrications, and evolving horn-like growths.

6. Mohair.

7. Alpaca, the successful staple of the great Saltaire industry.

8. Merino.

9. Australian botany wool.

10. Diseased wool fibre.

11. Kempy wool fibre; absence of imbrications or serrations in part.

12. Silk bave and brin, in contact and separated; also sections of silk.

13. Silk bave, or double thread of unequal diameters, reeled from bave of middle and end of cocoon thread.

14 Tussur bave, or double fibre, showing striations flattish or tape-like form; also sections.

15. Tussur bave, showing artificial separation of fibrets, comprising each brin.

16. Silk of *Saturnia carpini*.

17. Spider silk.

* "Fibrous Plants of India." Forbes Royle. Smith and Elder, 1855.

DISCUSSION.

Mr. M. Blair (Glasgow) said he had recently had the opportunity of visiting India, and might say a few words about the wild silks of that country, to which he thought silk manufacturers in England had chiefly to look in the future. One of the first things which struck a visitor to India was the enormous resources of that great empire, the vegetable, animal and mineral, thoroughly explaining why it was that all the great nations which had held the East and West traffic had flourished so exceedingly—from the Babylonians and Phœnicians down to the English. The second thing, however, which struck him, was the unreliable character of the people; the apathy and indifference to all ideas of improvement and advancement was something which an Englishman, and certainly which a Scotchman, could hardly comprehend. In India there was a large population living, and content to live, on the verge of starvation, and if you increased their income, one of two things took place. Either they worked half-time, and so reduced their income to what it was before, or they added additional mouths to eat it up. Thus it was found that when rice was cheap, the work-people went away for half of the week and left the machinery standing idle. This had an important bearing on the silk question. A vast quantity of silk material could be procured from India, but it would always be of poor quality unless it were prepared under European supervision. The silk was good, but it was not well reeled, and the people were too indifferent to improve it. The one thing needed for the resuscitation of the English silk trade was a large supply of cheap and good material, and for that they might look to India, not only from the *Bombyx mori*,

but from other and indigenous kinds which Mr. Wardle had devoted so much time and study to; but it must be reeled better. He feared this would never be the case if they trusted only to the natives. Anything which required no very skilled labour, such as rice-growing, or perhaps cotton, they did very well, but where skill was required, they could not be depended on. If they had been trusted to grow tea, and prepare the leaves, there never would have been any Indian tea worth speaking of, but under European supervision, this trade had grown enormously. The same policy should be pursued with regard to silk, and the machinery should be, as far as possible, automatic.

Mr. BIRCHENOUGH (Macclesfield) said good reeled silk was essential to the progress of the manufacture. He had not had much to do with Tussur silk, but he could see a great future for it if it were well reeled. The whole country, and especially the silk trade, were much indebted to Mr. Wardle for his investigations.

Mr. WELLS said Indian Tussur raw silk was practically unknown to the London trade, and asked if Mr. Wardle alluded to that or to China, when he said that a large quantity was imported.

Mr. WARDLE said he referred to China Tussur, from Shanghai.

Mr. WAILLY said he knew very little about silk, though he had done something to introduce new species of silkworm into Europe. He had lately seen carded silk from various species, such as Indian Tussur, *Pernyi* from North China, and some from North America. He had sent specimens of these carded silks to the Paris Acclimatisation Society. His main work had been the introduction of the insects, and he had no doubt that, this year, the Indian Tussur *Mylitta* would be acclimatised in Spain, and perhaps in some parts of Italy, though it would hardly suit the northern parts of that country, as it would take three months to rear.

Mr. ERNEST HART said, he knew nothing about silk, but as one of the general public he felt deeply interested in some of the facts stated in the paper. He was much struck with the fact that some silks largely sold here only contained one-seventh or one-eighth of pure silk; and that they were manufactured chiefly for the benefit of French manufacturers, though there was no doubt that England possessed special skill both in dyeing and weaving, and also a climate peculiarly fitted for the treatment of silk. It was evident, therefore, that there must be some other element necessary for the restoration of the industry, and he gathered that that element was better technical education. If that were so, perhaps Mr. Wardle could tell them in what special direction their efforts should be turned; for he was evidently one of those men to whom this country owed so much, who added to indomitable energy, and skill, and industry, scientific tastes. He believed no industry could be considered in a hopeless state which had such men in its ranks.

The CHAIRMAN having proposed a hearty vote of thanks to Mr. Wardle, which was carried unanimously,

Mr. WARDLE, in reply, after thanking the meeting for the compliment, said his principal feeling in this matter was one of anxiety and disappointment at the great loss which this country had sustained within the last thirty years, by the gradual decay of the silk industry. It behoved everyone who was anxious to regain it to set about the work at once. It was a melancholy fact, which could not be repeated too often, that for the last ten years the average value of manufactured silks imported into England from European countries had been twelve millions sterling, and he believed Mr. Birchenough would bear him out that if English manufacturers received orders for one-third that amount, it would make the silk centres of Coventry, Macclesfield, Congleton, Manchester, and Spitalfields, very busy indeed. In reply to Mr. Hart's question as to what he suggested, he would say study carefully the report of the Commissioners on Technical Education, for if he understood it aright it contained everything necessary to regain not only that, but any other artistic industry, either European or Eastern. It was a most valuable report, and he was sure it would do a great deal of good. It contained a vast amount of information, and the deductions which the Commissioners had drawn from their travels and observations were such as would enable any energetic person in time to overcome any difficulties. Mr. Wardle concluded by drawing attention to and describing the various specimens of silk exhibited.

The CHAIRMAN remarked that the particular researches of which Mr. Wardle had given some account, were undertaken at the instance of the Chamber of Commerce of Lyons, and had been followed by that body with the greatest interest. Although there were already excellent technical schools at Lyons, a special laboratory had been added in consequence of these researches. He drew special attention to this fact, because it was one of those significant things which showed the difference between the mode of operation here and abroad. We always had able and enterprising manufacturers, but they were left to their own unaided efforts, stimulated by competition; whereas, abroad, those who had a common interest were banded together in a strong organisation which cooperated for the welfare and advancement of their particular industry. Such was the case at Lyons and elsewhere. In every industrial centre in England there was a need for the same kind of thing; and if they could ever hope to recover these industries, it must be by

imitating the commercial spirit shown by our competitors abroad. He knew that many felt this difficulty, and until they could bring to bear not merely individual enterprise and generosity, which was undoubted, but also something like the aid of public funds wisely administered, for the promotion of that which was known and acknowledged to be the greatest public good, they would fail in competition with our, in some respects, wiser, and in many respects more successful, competitors on the Continent.

Miscellaneous

INTERNATIONAL INVENTIONS EXHIBITION.

OPENING CEREMONY.

H.R.H. the Prince of Wales, who will be accompanied by H.R.H. the Princess of Wales, will open the Exhibition at 12 o'clock on Monday, the 4th of May. His Royal Highness will arrive at the main entrance, and will thence pass through the galleries on the eastern side of the Exhibition to the Conservatory, where the formal ceremony of opening will take place. After the ceremony, His Royal Highness will proceed through the galleries on the western side of the Exhibition back to the main entrance. Holders of special tickets of admission to the Conservatory will be admitted by the upper entrances in Exhibition-road, or in Queen's-gate, according as their seats are at the eastern or western side of the Conservatory. Season-ticket holders, who wish to be present at the opening ceremony, will be admitted through the Albert Hall, whence they will gain access to the Conservatory. Season-ticket holders who prefer to be in the Exhibition itself during the visit of their Royal Highnesses, can enter at the main entrance up to 11.15. Until after the conclusion of the opening ceremony, there will be no admission from the Exhibition itself to the Conservatory, except for those holding special tickets. Season-ticket holders, therefore, will not be able to pass to the Conservatory from the Exhibition, or to the Exhibition from the Conservatory, until after the ceremony is over. Complimentary tickets admitting to the Exhibition Buildings are available from 10.15 to 11.15 a.m., or from 2 to 10 p.m. at the main entrance, Exhibition-road only. After 2 p.m. the public can obtain admission on payment of 2s. 6d. The following bands will play during the day in the various parts of the Exhibition and gardens:—Grenadier Guards, Coldstream Guards, Scots Guards, Royal Artillery, Mounted Artillery. In the afternoon there will also be organ recitals in the Albert Hall, and in the evening the combined bands of the Grenadier, Coldstream, and Scots Guards will perform in the Albert Hall. There will be fountain displays in the morning, in the afternoon, and in the evening.

The Railway Guide and Route Book of the Exhibition, compiled by J. R. Somers Vine, is now published. It contains an alphabetical list of places within thirty miles of London, with the names of the railway companies, the terminuses or junctions, the fares, and the hours of the last trains, as well as other information necessary for the visitor.

MEETINGS OF THE SOCIETY.

MAY 6.—"Nobert's Ruling Machine." By J. MAYALL, jun.

MAY 13.—"A Marine Laboratory as a Means of Improving Sea Fisheries." By Professor E. RAY LANKESTER, M.A., F.R.S. E. L. BECKWITH, Prime Warden of the Fishmongers' Company, will preside.

MAY 20.—"The American Oil and Gas-fields." By Professor JAMES DEWAR, F.R.S.

INDIAN SECTION.

Friday evenings at Eight o'clock.

MAY 1.—"Herat." By Professor VAMBERY. Sir T. DOUGLAS FORSYTH, K.C.S.I., C.B., will preside.

[Admission to this meeting will be by tickets only.]

MAY 8.—"The Ancient and Modern Methods of Treating Epidemics of Small-pox in India." By Surgeon-Major ROBERT PRINGLE, M.D., late Sanitary Department H.M. Bengal Army. Sir PHILIP CUNLIFFE-OWEN, K.C.M.G., C.B., C.I.E., will preside.

MAY 15.—"The Golden Road to South-Western China." By R. K. DOUGLAS, Professor of Chinese at King's College, London. The Hon EDWARD STANHOPE, M.P., will preside.

CANTOR LECTURES.

Monday Evenings at Eight o'clock.

The Seventh and concluding Course, "The Manufacture of Toilet Soaps." By C. R. ALDER WRIGHT, D.Sc., F.R.S., F.C.S.

LECTURE I. MAY 4. — Distinctions between Toilet and Household and Scouring Soaps—Early Historical references to Soap-making—Chemical Characters and Nature of Soap-making Processes in general.—Raw Materials: Alkalies and Acids; Fats and Oils; Glycerides, &c.—Hard and Soft Soaps: Ammonia Soaps—Classification of Manufacturing Processes, and Subsidiary Operations—Watering of Soaps—Some novel points in connection with the Chemistry of Soaps.

LECTURE II. MAY 11.—Plant and Appliances used in Soap Manufacture—Soaps made from free Fatty and Resinous Acids—Soaps made without Separation of Glycerine—Manufacture of "Boiled" Soaps, not containing Glycerine—Manufacture of Toilet Soaps—Recent Improvements—Manufacture of Milled Soaps.

LECTURE III. MAY 18.—Manufacture of Spirit-made Transparent Soaps—Machinery and Appliances employed in the preparation of Bars and Tablets—

Cutting and Shaping—Squirting, cold and hot—Stamping and Drying—Valuation of Toilet Soaps by Chemical Analysis—Classification of Toilet Soaps in accordance with the results of Chemical Analysis—Qualities requisite in Soaps intended for Delicate Complexions and Tender Skins.

A letter from Dr. Alfred Carpenter, in answer to Mr. Buchan's, will be published in next week's number of the *Journal.*

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 4...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. C. R. Alder Wright, "The Manufacture of Toilet Soaps." (Lecture I.)

Farmers' Club, Inns of Court Hotel, Holborn, W.C., 4 p.m. Mr. J. R. Fowler, "Farm Poultry."

Royal Institution, Albemarle street, W., 5 p.m. General Monthly Meeting.

Engineers, Town-hall, Caxton-street, Westminster, S.W., 7½ p.m. Mr. W. Newby Colam, "Cable Tramways."

Chemical Industry (London Section), Burlington-house, W., 8 p.m. 1. Messrs. Giles and Shearer, "Strength of Aqueous Solutions of Sulphurous Acids." 2. Discussion on Professor Munro's paper, "The Manurial Value of Filter Pressed Sewage Sludge."

British Architects, 9, Conduit-street, W., 8 p.m. Annual Meeting.

Medical, 11, Chandos-street, W., 8½ p.m. Annual Oration.

Asiatic, 22, Albemarle-street, W., 4 p.m. Mr. T. H. Thornton, "The Vernacular Literature and Folk Lore of the Panjaub."

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Professor Duns, "The Theory of Natural Selection and the Theory of Design."

Inventors' Institute, Lonsdale-chambers, Chancery-lane, W.C., 8 p.m. Further Discussion of Patent Law of 1883, Sections 22 and following.

Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. W. Matthews, "The Influence of Taxation upon Rent."

TUESDAY, MAY 5...Royal Institution, Albemarle-street, W. 8 p.m. Professor Gamgee, "Digestion and Nutrition." (Lecture VIII.)

Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Adjourned Discussion on Professor H. S. Hele Shaw's paper, "Mechanical Integrators." 2. Mr. A. M. Thompson, "The Signalling of the London and North-Western Railway."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m. 1. Mr. R. N. Cust, "Excavations in Progress, or lately Completed in Egypt." 2. Mr. E. Revillout, "Notes on some Demotic Documents in the British Museum."

Zoological, 11, Hanover-square, W., 8½ p.m.

WEDNESDAY, MAY 6...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. J. Mayall, jun., "Nobert's Ruling Machine."

Entomological, 11, Chandos-street, W., 7 p.m.

Archæological Association, 32, Sackville-street, W., 4½ p.m. Annual Meeting.

Obstetrical, 53, Berners-street, W., 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7½ p.m. General Meeting.

THURSDAY, MAY 7...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. Jas. J. White, "Germination of Seeds after long Submersion in Salt Water." 2. Mr. J. Starkie Gardner, "Fossil Ferns of the British Basalts."

Chemical, Burlington-house, W., 8 p.m. 1. Ballot or the Election of Fellows. 2. Dr. J. H. Gladstone and Mr. Tribe, "The action of the Copper Zinc Couple on Organic Bodies." (Part X.) "Benzine Bromide." 2. Professor W. N. Hartley, "Researches on the Relation between the Molecular Structure of Carbon Compounds and their Absorption Spectra." 4. Sir J. B. Lawes and Prof. Gilbert, "Some points in the Composition of Soils, with results illustrating the sources of Fertility of Manitoba Prairie Soils."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Conversazione at the Galleries of the Royal Institute of Water Colours, Piccadilly, W.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Tyndall, "Natural Forces and Energies." (Lecture IV.)

Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Mrs. Shiel, "Physiology and the Laws of Health." (Lecture X.) "The Nervous System."

Archæological Institution, 16, New Burlington-street, W., 4 p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Special Lecture. "The Theory and Practice of Hydro-Mechanics." (Lecture VI.) Sir Edward Reed, "Forms of Ships."

FRIDAY, MAY 8...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Dr. Robert Pringle, "The Ancient and Modern Methods of Treating Epidemics of Small-pox in India."

United Service Institution, Whitehall-yard, 3 p.m. Vice-Admiral J. H. Selwyn, "Development of Liquid Fuel for Marine Purposes."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Mr. W. F. R. Weldon, "Adaptation to surroundings as a Factor in Animal Development."

Astronomical, Burlington-house, W., 8 p.m.

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

New Shakspere, University College, W.C., 8 p.m. Musical Entertainment. Third Selection of Shakspere Madrigals, Glees and Songs, in chronological order, under the direction of Mr. James Greenhill.

SATURDAY, MAY 9...Royal Institution, Albemarle-street, W., 3 p.m. Mr. W. Carruthers, "Fir Trees and their Allies." (Lecture III.)

Physical (Meeting at Bristol). 1. Professor W. Ramsay and Dr. S. Young, "Evaporation and Dissociation." 2. Prof. H. S. H. Shaw, "A Self-recording Stress and Strain Indicator." 3. Prof. S. P. Thompson, "A Model Illustrating the Propagation of the Electromagnetic Wave, and a New Curve Writer." 4. Mr. W. A. Shenstone, "Note on the so-called Silent Discharge of Ozone Generators."

Geologists' Association, University College, W.C. Excursion to the Deneholes at Grays Thurrock, under the direction of Messrs. T. V. Holmes and W. Cole.

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Journal of the Society of Arts.

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FRIDAY, MAY 8, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

INTERNATIONAL INVENTIONS EXHIBITION SEASON TICKETS.

The Executive Council of the International Inventions Exhibition have consented to allow Members of the Society of Arts the privilege of purchasing Season Tickets for the Exhibition at half-price (10s. 6d.) Any member desiring to avail himself of the privilege can obtain a ticket by applying to the Secretary, and remitting the price, 10s. 6d. Each member will only be allowed the privilege of purchasing a single ticket on these terms, which will be a personal admission, not transferable. It will be understood that all applications must be accompanied by the above-named remittance, and that tickets at the reduced rate can only be obtained from the Secretary of the Society.

CANTOR LECTURES.

The first lecture of the seventh and concluding course was delivered by Dr. C. R. Alder Wright, F.R.S., on "The Manufacture of Toilet Soaps," on Monday evening, 4th inst. The lecturer commenced by pointing out the distinctions between toilet and household and scouring soaps, and after referring to the historical portion of his subject, explained and illustrated by experiments the chemical characters and nature of soap-making processes. He described the raw materials used, and drew special attention to the injurious effects of an excess of alkali. In conclusion, he explained some novel points in connection with the chemistry of soaps.

The lectures will be printed in the *Journal* during the autumn recess.

Proceedings of the Society

FOREIGN & COLONIAL SECTION.

Tuesday, April 28, 1885; the Right Hon. W. E. Forster, M.P., in the chair.

The Chairman, in introducing the reader of the paper, expressed the pleasure which it gave him to preside that evening, as he felt great interest in the subject to be discussed, and also because he knew that Mr. Gorst was well qualified to speak upon the subject, and he was also able to give the proof, if proof were necessary, that those who were in favour of the federation of the colonies were free from any party feeling in supporting the movement, the author and himself having never sat on the same side of the House of Commons. He would only make two remarks, which would certainly be deemed appropriate, and which he thought it would be hardly becoming not to make on such an occasion. One was that our kinsmen in New South Wales had given additional proof of their loyalty and of their willingness to risk life and spend money for the Empire and their Queen, by making the offer to send their men not only to the Soudan, but to the war, if there should unfortunately be a war, which he trusted there would not, in India. In the second place, while they rejoiced in these proofs of sympathy, they also should themselves sympathise with their fellow-subjects in Canada, who were compelled to undertake operations for the suppression of a rebellion. They all remembered when there was a disturbance in the same district which had to be put down by forces sent from this country. Then it was a Crown colony, but now it was a portion of the Dominion. But that was no reason why we should not sympathise with those who had shown sympathy to us, and who were manifesting an energy and courage of which all might be proud. The wisdom and moderation expressed by Sir J. Macdonald and the Government of Canada in exhibiting a readiness to consider and remove any grievance which could fairly be made evident, while feeling it their duty to suppress an agitation directed not only against the authority of the Queen, but against life and property in the colony, were deserving of all thanks and praise.

The paper read was—

THE FEDERATION OF THE EMPIRE.

By J. E. Gorst, Q.C., M.P.

I have been asked to read a paper at this meeting for the purpose of opening a discussion concerning what is called Imperial Federation. I shall purposely pass lightly over those principles in the relations between the United

Kingdom and the Colonies which may be regarded as settled and beyond the region of controversy, and dwell upon those in reference to which general opinion is still held in suspense. The practical end to be aimed at in all discussion of the subject, both in the mother country and the colonies, is to arrive, if we can, at a common consent as to the direction in which change or development in the principles not yet settled is to be looked for, and as to the practical measures by which effect can be given to our conclusions.

From the colonial point of view the case has, until recent times, stood thus. The people of a self-governing colony have enjoyed absolute freedom in the management of their internal affairs; they have taxed themselves, regulated their own domestic government, and made their own laws. But in external affairs everything has been managed for them. They have not only had no voice and no control over the Foreign-office of the United Kingdom; they have often been left in complete ignorance of negotiations upon matters in which their interests were specially involved. They have not unfrequently learnt the sacrifice of their wishes for the first time as an accomplished fact, when even protest and complaint had become futile.

The people of the United Kingdom, on the other hand, have been left to bear alone the burden of empire. The utmost duty of a colony was to provide for the defence of its coasts and harbours. The army which upheld the power of the Empire abroad, the navy which protected its commerce on the high seas, the dockyards, arsenals, and coaling-stations, have been maintained at the sole cost of the taxpayers of the United Kingdom. The interest which they have in this is paramount, but not exclusive; a large part of the expenditure is for the benefit of their colonial fellow-subjects as much as for their own.

The complaint on one side has been closely related to that on the other. Colonies cannot have a voice in Imperial affairs, unless they share the cost of maintaining Imperial interests. The United Kingdom cannot ask the colonies to contribute to the cost of Empire, unless she admits them to their legitimate share with herself in the Imperial councils.

I have purposely used the past tense in describing, as I have done, the attitude of the mother country and the colonies upon this question. For matters have been already, for some little time, in a state of transition. On the one side, the exclusiveness of the Foreign-office has already been broken through. In recent negociations respecting the Western Pacific with France and Germany, information has been voluntarily given to the Australian colonies which they would not have dreamt of asking for some years ago. The views and wishes of the colonies have even been taken into the consideration of the Foreign-office as one of the elements of the case. On the other side, in the crisis, when Khartoum fell, the colonies came forward, and offered to bear part of the burden of the Soudanese war. This was going even beyond anything which reciprocal duty of defence might be thought to require. It was not a case in which the common interests of the Empire were involved so clearly as in some circumstances that might be conceived. The war was not undertaken by the United Kingdom for the defence of the Empire, it was forced on her as part of the obligations assumed by her in reference to the government of Egypt. The interests of the great powers of Europe were as much involved as those of Great Britain, and more than those of the colonies; but if the colonies were willing to contribute to extricate the mother country from a scrape, there can be no doubt they would be ready to do the same thing in the case of any joint enterprise undertaken for a common purpose.

Recent events have thus established a reciprocal willingness on the part of the mother country to admit the colonies to some share in the councils of the Empire, and on the part of the colonies to bear some share of Imperial burdens. The occasion is, therefore, a favourable one for considering to what extent the principle of common action may be carried, and by what means common action may be effected.

There are three distinct lines upon which a closer union between the mother country and the colonies may be developed.

(1.) The admission of representatives of the colonies to the Legislature of the United Kingdom, which is at present the body which controls, or is supposed to control, the Executive Government of the Empire.

(2.) The creation of a new Imperial Legislature paramount in all Imperial matters over the Legislatures of Great Britain and the Colonies, which should represent every part of the Empire, and be capable of acting for its common interest.

(3.) The admission of the colonies to a more

direct share in, or stronger influence upon, the Executive Government of the Empire, the several Legislatures remaining entirely separate from, and independent of each other.

Whichever of these three may be the form upon which the relations between the several parts of the Empire may be ultimately established, the final constitution must be the result of gradual—possibly of slow—growth. No one thinks of manufacturing a paper constitution to which the mother country and the colonies shall be expected to conform. There may be an advantage in knowing in what direction we are moving, there is none in accelerating our progress, even if it were possible to do so, by violent means.

As I am writing this paper to initiate discussion rather than to persuade, it will conduce to clearness, if I state beforehand, the conclusions which the rest of this paper will attempt to establish.

The introduction of representatives from the colonies into the Houses of Lords and Commons, would not produce the effect anticipated by those who propose it. The British Empire is not now governed by the British Parliament. It is governed, as every civilised community is in modern days, by bureaus of permanent officials, very partially and imperfectly controlled even by the Ministry of the day. The responsibility of either permanent officials or ministers to Parliament, is daily becoming more of a delusion. A colonial peer, or a colonial member of the House of Commons, would find himself in a hopeless position of impotence. The House of Lords has already lost most of its authority, and is daily surrendering the residue by its own abstention from affairs. The majority of the House of Commons is powerless to assert its own judgment against the Ministers of the day, so long as the latter retain the confidence of the constituencies.

The second plan for establishing a new and paramount Imperial Legislature does not seem to me to be either now within—or likely ever to come within—the range of practical politics. In theory it would bring about a much closer union than any other. But I doubt whether a very close union is desirable. It does not seem to me to be either possible or expedient if it were possible to alter the independence and individuality of the colonies as they now exist. I think the objects for which common action is necessary can be attained without such change. It would involve the surrender by the various colonial legislatures of some of their present powers, and by the British Parliament of its nominal supremacy. Nothing short of a revolution could effect so radical a change, and I do not see where the moving force for such a revolution is to come from. The colonies would never consent to abridge in the slightest degree the liberty they at present enjoy. I think most of them, if driven to the choice, would sacrifice the union with the mother country rather than their independence.

The plan which seems to me to be alone practicable is to recognise the right of the colonies, through their representatives, to exercise direct control over the administration of Imperial affairs. Though it is not expressly acknowledged, they have already, indirectly at least in foreign affairs, a good deal of such control. It has been exercised by the Australian colonies on many occasions during the last year or two. The recognition, regulation, and development of this power appears to me the direction in which the federation of the Empire should and will proceed.

Those who look to a common administration and common legislature as the ultimate form of federation, will ask whether there are not other objects besides defence and foreign policy in which common action is desirable. I am ready to admit that there are many now existing, and many more may arise hereafter. I know of none that cannot be attained with the complete legislative separation that now exists. At present at least it is only in questions of defence and foreign policy that any change or development is necessary.

I cannot resist the idea that some of those who advocate a very close union of the Empire are animated by a secret motive: they wish for a mild coercion of the colonies by Great Britain in favour of free trade. The German Zollverein is quoted as a precedent. There is little analogy between the cases. The States of the Zollverein were driven into union by necessity : they could not have independent tariffs. In the British Empire complete independence of fiscal policy has existed for years. The only object of union would be to abridge the discretion which each colony has so long possessed of levying what duties it pleases on British manufactures. If the idea of federation is to make any progress in the colonies, we must in this country abandon all thought of any prospective interference with colonial tariffs. As far as customs duties are levied for purposes of revenue, the colonists have the sole right to decide whether such a method of raising their revenue is economically sound or not. In new

and sparsely populated countries nearly the whole proceeds of a direct tax may be swallowed up in the cost of collection; duties levied at the few ports of entry may be the cheapest form in which people can contribute. Taxes which are levied for purposes of protection most of us in this country would agree in condemning as economically unsound. But the colonists must be left to find out their mistake, if it is one, for themselves. Having given up long ago the claim to think and act for them, we must be content to see them follow their own judgment in the matter, even when we think it wrong. Their freedom in domestic legislation cannot be conditional in our approval of the use they make of their right. Uniform law can exist in the British Empire without a common legislature. A general uniformity in spirit, a very considerable identity in the letter, exists throughout the Empire at this moment. If further assimilation is required, it can be obtained in the future as it has been in the past, by mutual agreement. No practical difficulty has yet arisen, from the fact that each legislature is independent, and could enact the most diverse law if it pleased. Confidence in the stability of the laws common to the Empire is not shaken, because these laws are applicable to each colony so long only as it pleases. The existence of the Committee of Privy Council as a Court of Appeal is useful in preserving the uniformity of law, and valuable as a visible bond of union, although it could not be imposed upon an unwilling colony. If Canada or New Zealand thought fit to establish a Court of Final Appeal of their own, they would be strictly within their rights in doing so, but these are rights they are not likely to exercise. Colonies must retain the power to enact what laws they please upon such subjects as marriage and currency. However much uniformity may be desirable, it cannot be attained by interference with legislative independence. Common interest and common convenience are the only motives to be appealed to, and anything like coercion for the purpose of securing a common benefit would be only the certain means of defeating the desired end. I will refer to one matter on which common agreement is desirable, though it is one of too complicated a character to be discussed in a parenthesis—the law of British shipping. There is no such thing as a colonial ship. A ship built and registered in New Zealand is a British ship; is subject to the statute law of the United Kingdom, which can override even the statute law of the colony itself. The moment she leaves the territorial limits of the colony, reaching three miles from shore, all her crew cease to be subject to New Zealand law and to the jurisdiction of the colonial courts, and become subject to British law and to the jurisdiction of the Imperial Courts of Admiralty. The difficulties to which this state of law gives rise are incurable by colonial legislation; no colonial law can have any validity beyond the limits of the colony in which it is enacted. The law of British shipping is the only subject I am aware of on which joint legislative action is desirable. The necessary result could be attained even in this matter by an Imperial statute passed in accordance with the wishes of the various colonial legislatures. A common legislative body is not necessary for the purpose.

If the conclusions so far arrived at are correct, it follows that the objects for which federation is to be promoted may be regarded for the present as limited to two—defence and foreign policy.

We proceed, then, to inquire how the just proportion in which a colony should contribute to the Imperial army and navy is to be ascertained, and to what extent its right to influence or interfere with the Executive Government in its management of the army and navy, and in the regulation of foreign policy, ought to be admitted. The expenditure of the mother country on the army and navy is for two distinct purposes; it is partly incurred for domestic defence, and partly for external and Imperial objects in which the whole empire possesses a common interest. In the estimates and accounts of the United Kingdom, no division of expenditure under these two heads is made. This would have to be done before the colonies could be called on to contribute, as it is only the expenditure under the latter head that they could be justly asked to share. Of the British army, a large part is maintained for the service of India, and its cost borne by the revenues of India. Another large part is required to preserve order in Ireland. This unfortunate necessity must be looked upon as a burden peculiarly incumbent on the United Kingdom, which the colonies could not be fairly required to help to bear. Another part of the army is necessary for the defence of our coasts and harbours. This the mother country rightly keeps up at her own exclusive cost. Most of its colonies have an analogous force of their own, to which none of them dream of asking the United Kingdom to contribute.

I had taken steps to procure some interesting particulars in reference to the colonial forces, which I should like to have placed before the Society, but I have been advised that it is, at the present moment, inexpedient, for various reasons, to publish the exact details of colonial forces, either military or naval; I must, therefore, content myself with merely reminding the Society of their existence.

The only part of the army which subsists in time of peace for strictly Imperial purposes, is that portion which is held constantly ready for service in any part of the world in which an emergency may arise. Theoretically, such a force should be maintained at the cost of the Empire, and not of the United Kingdom alone. The colonies might fairly agree to some fixed money contribution for such a purpose, with such stipulations as to the control of the expenditure, and the accounts to be furnished to each contributor, as might be determined upon. But colonial contribution to the Imperial army is more likely to assume another shape, in which the military individuality of each colony would be preserved. Each colony might undertake to so settle its military arrangements as to keep a given force always ready for an emergency, which could be dispatched to join the forces of the United Kingdom, and of other colonies, in any operation decided upon as necessary for the general welfare. The recent offers of troops for service in the Soudan, by the Australian Colonies and Canada, seem to show that such a plan would not be unacceptable to the colonies, and the example of the New South Wales Contingent proves the promptness and efficiency with which it is capable of being carried out. It seems, therefore, that as far as army expenditure is concerned, no great alteration in the present arrangements is necessary.

The case of the navy, however, differs much from that of the army. Some of its expenditure is no doubt incurred for domestic purposes. The defence of the narrow seas surrounding the British Islands, and of their ports and harbours, are, and should remain, the exclusive concern of the mother country. The cost of the ships, the submarine mines, the torpedoes, the shore batteries, kept and employed for this purpose, falls justly upon the taxpayers of the United Kingdom. But the greater part of the navy is not maintained for the defence of Great Britain. It is spread over the whole world. It protects the commerce of the whole Empire. It is ready to defend the shores of any one of the colonies that may be threatened. It upholds the supremacy of the British power upon the high seas, which constitute the connection and communication between the various parts of our scattered empire. It is true that some of the colonies and dependencies of Great Britain have naval forces for the defence of their own harbours; such ships are, however, analagous to those kept for the defence of the British Islands. In those colonies where they exist they correspond at most to the Channel Squadron. To the Imperial fleets in the Mediterranean, in the seas of North America and the West Indies in the Pacific Ocean, in the China seas, in the Indian Ocean, in the Australian seas, at the Cape of Good Hope, and on the Coast of Africa, nothing in the colonies or dependencies corresponds. The cost of the dockyards where the ships for these fleets are built, of the arsenals where they are armed, of the coaling stations where they are provided with fuel, the pay, victualling, and maintenance of their crews is a matter of strictly Imperial concern. The burden is now borne exclusively by the 36,000,000 people of the United Kingdom. They, as the largest section of the British community, have no doubt the greatest interest in upholding our naval supremacy, but, in proportion to their number, the interest of the people of the colonies, by whom no part of the burthen is borne, is just as great. Contribution to the Imperial navy could not be so well arranged, as in the case of the army, as a contribution in kind. The colonies can supply contingents of men to form an Imperial army; they could not conveniently supply contingents of ships. The contribution would have to be in money, and the Imperial navy would have to be a joint undertaking of Great Britain and her colonies.

Besides the Imperial fleet, the mother country and each colony might, if it thought fit, keep up its own domestic navy for home defence. But there would be no advantage in having several separate navies, and the Imperial navy might advantageously supply such ships as are required for local defence. The British Admiralty seems, at one time, to have thought otherwise, and by compelling the Victorian ships to strike the white ensign, drove the colony as far as they could into naval separation. But they would probably not act in this manner again. Of course ships employed in local defence would be paid for by the colony which applied for them, and would be at the sole disposal of its Government. The cost of the Channel fleet, and of all ships em-

ployed in the protection of Great Britain and Ireland, would, on the same principle, be defrayed exclusively out of the taxes of the United Kingdom. Whenever the time comes that the colonies recognise their obligation to contribute to the general naval defence of the Empire, the representatives of the colonies in London will have to arrange, in concert with the British Ministers, the amount of expenditure to be incurred in each year for maintaining the Imperial navy, and the proportion which each colony should contribute. The colonies have already representatives in London competent to discharge such a function, or they could appoint special delegates if they pleased.

Nothing is more remarkable in the history of the relation between Great Britain and the Colonies than the growth of the functions of the Agents-General in London. These officials were at first mere financial agents, with duties narrowly limited. They have now access to every department of the British Government which deals with matters of Imperial concern. They not only give information and advice, but they conduct actual transactions for the general benefit of the Empire. The electric telegraph keeps each of them in the closest touch with the Government from which he is accredited. He speaks, not like a member of the Council of India, who expresses his own views and nothing more, but as the mouthpiece of a Government which represents a considerable section of the British people, able to give substantial aid to the common cause.

The estimates for, and the accounts of, naval expenditure could be regularly submitted to the colonial representatives. The Admiralty would settle in conference with them its policy and the proportion each colony should contribute; they would possess exactly the same sort of ultimate power over naval administration that the House of Commons still retains. Each colony would have, as its last resort, the right to refuse its quota of the supply.

There would probably be no actual saving of money to the British taxpayer in such an arrangement. The colonial contribution would go to increased efficiency, and not to reduce the naval expenditure of the United Kingdom. But it would not be the navy alone that would be improved; it would be the Board of Admiralty as well. There is no conventional statement more untrue than the common one that the British Admiralty is under the control of the House of Commons. The Admiralty is a bureaucracy of an antiquated and exclusive type. The amount which it is permitted to spend is limited by another bureaucracy—the Treasury—but subject to that limitation, it is under hardly any control whatever. Its administration is occasionally criticised in the public press by naval officers, and other persons possessing—or thinking they possess—the necessary technical knowledge; but questions of naval architecture are beyond the capacity of the people, and it is impossible to rouse public opinion to such an extent as to affect the stolidity of the Board. The naval debates in the House of Commons are a mere repetition of what has been already urged in the press; the speeches lack the charm of novelty, and lack the effect they might produce if the Minister responsible for the navy were present to defend the administration. This functionary has been relegated, in modern times, to the House of Lords, where no naval criticism ever takes place, and where no one could pay any attention to it if it did. The Treasury control is a one-sided one, it is only a safeguard against over-expenditure. As long as the Admiralty keeps on the side of spending too little, it does not feel the Treasury influence at all; the bureau is as absolute and unchecked in its administration as the Admiralty of Russia. If all the colonies had representatives in the House of Commons and the House of Lords, they would find that they possessed as little voice in the naval administration of the Empire as they have at the present moment. But if the naval policy of the Empire was discussed by a body in which the British Ministers and all the Colonial Governments were represented, and of which each member could secure attention to his views by official protest, and in the last resort by refusal to contribute, some real control in the general interest of the Empire would be secured. One of the first Acts of such a body would be to open the naval service of the Queen in all its ranks to British subjects in every part of the Empire.

Colonies which contributed a fair share to the defence and maintenance of the Empire would have an irresistible claim to a voice in the conduct of its foreign affairs. Under the British Constitution, as it now exists, the commonly received theory is that foreign affairs are subject to the absolute control of public opinion; that at present the paramount authority by which they are directed is the will of the majority of the people of the United Kingdom; those who desire to give the

colonies their fair share in these matters believe that it is to be done by broadening the area of public opinion, and substituting the voice of the people of the entire empire for the exclusive judgment of part of the people only. This theory seems to me entirely erroneous. The error arises from the habitual use of conventional language in speaking of our institutions. Foreign policy, guided by the changes of a fickle and ill-informed public opinion, may be, as Prince Bismarck thinks, eminently undesirable; in this country, at any rate, such a state of things does not at present exist.

The foreign affairs of Great Britain are not at present conducted in accordance with the wishes of the majority of people in the United Kingdom. The paramount influence by which they are guided is the judgment of a body of men—the Ministry for the time being—selected by the Prime Minister. He, in his turn, derives his power from the sort of plebiscite which takes place at a general election. The Prime Minister and his colleagues may have acquired, perhaps years ago, the confidence of a majority of the electors, not because of their views of foreign policy, but in spite of them. Their individual judgments may be affected more or less according to the character of each by general censure or applause. It is in that indirect way only that public opinion operates. The general body of the electors of the United Kingdom are ignorant of foreign affairs, and take a very feeble interest in them as compared with matters which they think directly affect their welfare. Nothing but war or disaster, and heavy taxation as the consequence, compel a reluctant attention to such matters, and they are forgotten as soon as the urgency is passed. At every general election the people freely choose to which of two sets of men the government of the country for the next six years is to be entrusted. Among the motives which induce them to bestow their confidence on one party rather than another, questions of foreign policy play in most constituencies a very subordinate part. Having placed his party in office, the average elector surrenders his judgment on foreign affairs, in which he possesses no confident opinion of his own, to the statesmen of his choice. It would require extraordinary mismanagement and conspicuous disaster to cause a withdrawal of confidence on account of matters so far removed from his every-day experience. The conduct of foreign affairs by a British Ministry is only one among several grounds on which the confidence of the people necessary to their continuance in office is granted or withheld.

The small committee of English statesmen, by whom foreign affairs are really managed, ought, of course, to have regard in their action to the general interest of the Empire—to give as due weight to the interests of Canada or Australia, as to that of the United Kingdom. They would possess more than human virtue if they exhibited such impartiality. It is upon the people of the United Kingdom that their existence as Ministers depends, and it is the welfare of the United Kingdom that fills the field of their political vision. They do not always ignore the interests of the Colonies. It is not for the advantage of the United Kingdom that they should. But they regard them only so far as the benefit of the United Kingdom requires, and are often ignorant of what the Colonies desire. English diplomacy excludes the British from the New Hebrides without the knowledge or consent of the Australian Colonies, and leaves these islands, once a part of our dominions, a certain prey to France. English policy allows the occupation of Raiatea by France in direct violation of a treaty, and the English Foreign-office believes that the Australian Colonies have no interests in the Eastern Pacific. English diplomacy is now engaged in bartering French rights in Newfoundland against English rights in the Eastern Pacific, without the knowledge or consent of either Canada or New Zealand. An emissary of the English Colonial office sits down with Prince Bismarck in Berlin, and invites him to a partition of the Western Pacific, proposing a conspiracy to circumvent the susceptibilities of the Australasian Colonies. It should be impossible for steps of this kind to be taken until every colony has had the opportunity of stating whether it considers its interests affected, and if it does, of giving its reasons for or against any course which is proposed. If the Ministry of the United Kingdom must retain the "hegemony" of the British Empire, its decisions should at least be given in consultation with the representatives of the colonies, and after full consideration of the facts and arguments they may adduce. The colonies should also have some power of initiating Imperial activity. At present they are at the mercy of the dilatory negligence of the Colonial-office. In the Angra Pequena negotiation, the interests of the Cape Colony were jeopardised by the retention, under the consideration of Lord Derby, for five months,

of a dispatch of Count Münster. Angra Pequena was annexed by the German Government in the interval. If the Australian Colonies had been free communities, they would long ago have annexed that part of New Guinea which has since been acquired by Germany. Their connexion with Great Britain has cost them a territory which they think important for their interests. There is no more instructive and striking contrast than that between the treatment of the German authorities in the Western Pacific by Prince Bismarck, and that of the Australian Governments by the Colonial-office. In the former case, careful consideration was given to all representations made, and prompt action was finally taken in the interests of the German empire. In the latter case, the Governments were regarded as importunate beggars to be kept at arm's length. The main thought of the English Colonial-office was to avoid responsibility or expense; there was hesitation and timidity followed by rash action and ignominious retreat. The submission of all questions of Imperial policy to the consideration of a body in which the goverments of the Colonies as well as that of the United Kingdom were represented, would prevent such mismanagement, and secure the promotion of wide and generous aims.

The closer union between the several members of the Empire, which we all agree in desiring, should, in my judgment, be looked for, not in any fusion of the legislatures, but in a more intimate concert of the executives. If the people and Governments of Great Britain and the Colonies recognise this as an object to be aimed at; the particular form of the arrangement will work itself out better by practical experience than through theoretical discussion. This process of federation is in active operation at the present moment. Both the Foreign-office and the Admiralty give information to the Agents-General of the Colonies upon some matters of common concern, and receive and consider their opinions about them. Both these departments act on some occasions as agents for the colonies, and on some occasions invite the representatives of the colonies to act as agents for them. Complete union will be attained so soon as what is now the exception becomes the rule—when the colonies are taken into council in all matters of Imperial defence and Imperial policy, and when all objects of general interest are carried out by common and concerted action.

DISCUSSION.

Mr. Labilliere said he was sorry that Mr. Gorst should have suggested that the advocates of closer Imperial union, in the shape of a federal Parliament, had some policy lurking in the background of forcing upon the legislatures of the colonies a system of free trade. As one of those who had spoken and written upon the subject of Imperial federation, and having read the writings of people who had gone a long way upon the subject, he thought they were always particular to lay down as one of the main planks of their platform the retention of self-government by the colonies, and that the present legislatures in the colonies were to have the same complete control over fiscal matters as they at present enjoyed. He could not see how, if a federal Parliament were established, there need be any interference with the perfect freedom of action which now existed, and he did not see why a federal Parliament should interfere with the fiscal policy of New South Wales, or Victoria, any more than the present Imperial Parliament did. Therefore, he was sorry that Mr. Gorst should have said that the advocates of a federal Parliament had any such design in the background as to force upon unwilling colonies a fiscal policy of which they did not approve. With regard to the regulation of the defences of the Empire, Mr. Gorst had remarked that if they excluded considerations of fiscal policy from the operations of the federal Government, it merely came to a matter of that government having to regulate defence and foreign policy; but when they looked at these questions, they found they at once opened up a vast number of considerations of essential importance to all portions of the Empire, and which would require the deliberation not only of representatives, but also the action of an executive. They had been told, up to recent times, that there were no interests in common between the mother country and the different colonies requiring joint action or joint government; but, looking around them at the present moment, it might be said that every land and sea was bristling with our common interests. The most vital questions affecting England were questions vitally affecting the colonies. The advance of Russia in the East was a question which intimately affected the future welfare of Australia as much as it did England, because Russia in possession of India would occupy a more menacing position with regard to Australia than she would with regard to the British Isles, and this would necessitate an amount of defence to be kept up on the part of Australia of a very considerable nature. If we were to hold India in the future, it could not be merely by the strength of England but by the strength of the United Empire, and Australia would be a most important base for the defence of India, in the event either of a mutiny or invasion. Again, the Suez Canal was a subject which deeply affected our Eastern policy, and the Canal would be the only practical route for the Australian trade with the shores of

the Mediterranean. The real interests of England and the colonies are identical, and it would ultimately be essential, in order that these common interests might be sufficiently protected, to have something more than a mere consultative council in this country; they must have real representatives from the colonies, with power to impose a certain amount of Imperial taxation for carrying out Imperial purposes, and for maintaining Imperial defences. As an instance of the loyalty of the colonies, he might quote an extract from the speech of Mr. Dalley, the acting Premier of New South Wales, who, referring to the Soudan campaign, said, "As members of the Empire we should be defending ourselves, and all most dear to us just as much in Egypt as if the common enemy menaced the colonies. The Queen's enemies are ours wherever they may be." That Mr. Dalley, like himself, was a native of Australia, and had been brought up there, was a fact which he thought added additional weight to such words as he had quoted. Again, on the 24th of February Mr. Service, in response to a toast of the Ministry of Victoria, said "There had never been a time when Englishmen, no matter where they lived, ought to stand so determinedly shoulder to shoulder as now. Since he began to study politics, England had never been in such peril. The steps recently taken in Australia with regard to the Soudan would strengthen the mother country in the eyes of the world. Echoing the language used in England, he said the mother country would never want assistance while Australia had a man, a ship, or a shilling." Sir Alfred Stephens, of New South Wales, also said "that the colonies were prepared to sink or swim with the mother country." Considering the source from which these observations came, and the men who uttered them, the value of such expressions could not possibly be over-estimated.

Mr. Frederick Young said he was so much gratified with the paper which had been read, that he hardly felt disposed to take exception to any of the arguments which had been adduced. It seemed to him, after all, that the unity of the Empire could be best preserved by a proper representation of all its parts in a central government. Mr. Gorst had shown that there were three courses which might be adopted, the two first of which he emphatically condemned, and had given his adhesion to the third. He (Mr. Young), having long taken a deep interest in the question, and advocated views very comprehensive indeed with regard to the second of these courses, namely, an Imperial federation and a representative Parliament of the mother country and the colonies, thought that many of the arguments which Mr. Gorst had used were very much in favour of that course being adopted. He did not at all object to a perfectly representative system of the whole Empire which would carry out the old lines of the British constitution in every self-governing part of the Empire. If the British Empire was to be kept together, the ultimate solution would be an Imperial Parliament. What was required was representation with power, and it was of very little importance how that was effected if that principle was clearly and fully adopted. He also thought they should have an Imperial navy, to which the colonies should contribute, and have their fair share of patronage in it. It did not necessarily follow that the navy was to be managed exclusively by the Admiralty, as at present constituted. What was wanted was a change in the administration of the navy, which could only be done by enlarging the constitution, and allowing the colonies to participate in its management. Mr. Gorst was quite in error in saying that under any representative system, such as he proposed, the colonies would part with any portion of the control of their own affairs. The whole theory was that they should take part in Imperial matters, but that there should be no interference whatever with their own local affairs.

Sir F. Dillon Bell, K.C.M.G. (Agent-General of New Zealand) thought the peculiar advantage possessed by Mr. Gorst's paper was that they had been enabled, for the first time, to see the question from the colonial point of view. The discussions which had taken place hitherto had been upon theoretical and abstract principles, while the ascertainment of the feelings of the colonists themselves, with respect to the main issue presented, had been very much neglected. They were now beginning to recognise that they could not make any great advance in the question until they knew what relation the colonies themselves would be willing to take in their association in Imperial concerns in the future. Mr. Gorst struck the right chord when he advised them not to be too hasty in determining the form to be ultimately adopted for bringing together the colonies and the Empire more closely; but to be content for the present with resisting the advancing tide which threatened the disintegration of the Empire. While looking steadily to the time when the question must develop itself in a different way, they should hesitate before laying down any distinct declarations which might assist the enemy in the insidious suggestions so often made towards disintegration. With every deference to the views of Mr. Young and of Mr. Labillière, he must say he looked upon a federal Imperial Parliament as one of those things which they should hesitate before advocating in the very decided way in which some gentlemen had been in the habit of doing. The proposal for the Imperial federal Parliament might develop itself one of these days; but at present it would meet with a most formidable opposition, for it would be asking the Imperial Parliament of Great Britain to reduce itself from the position it had held for centuries, to descend from the Imperial sway which it had always exercised, and to sink into a secondary and

subordinate body. It must not be forgotten that at the present time the colonies were only at the very threshold of the exercise of the powers which the Imperial Parliament confided to them some 30 years ago; indeed, it was only 50 years ago that some of the great self-governing colonies were founded at all. In 1801, the first census showed that the population of England, Wales, and Scotland barely amounted to the present English population of the colonies, yet at that time England was confronting the world in arms, possessed great fleets and armies, and had accumulated an enormous national debt. The people of England had now increased from 10 millions (as it was in 1801) to 35 millions, and the rapid growth of the self-governing colonies was gradually reducing the disproportion in numbers between the mother country and the colonies. It would be time enough to raise the idea of a federal Parliament when there was some greater equality in the numbers of the population. They should rather seek some practical means by which the ordinary administrative relations of the Empire to the colonies could be carried on without friction or resorting to any great measures of change. The mere fact of the necessity which existed for a new kind of relation between the Imperial and the colonial Governments had already created that new relation, and was developing it every day. It was quite true, as Mr. Gorst stated, that only a few years ago the official representatives of the colonies were mere mercantile agents, with nothing of political work; but as the importance of the colonies had grown, they had been obliged to place themselves in more immediate relations with the Imperial Government, and to have access to the great departments of the Imperial Administration. But that had not interfered in any way with the autonomy of the colonies. The colonies exercised their power as they thought best, and were in no sense responsible to the Imperial Government for the exercise of the legislative powers which had been conferred upon them. But the moment you tried to lift them into the new relationship of a federal Parliament, you would touch one fundamental point of difficulty and danger, which he had never yet seen referred to by the advocates of federation, though it lay at the threshold of the question, viz., were the colonies to be liable to Imperial taxation? There was no doubt, the logical answer was yes, but why was it not avowed? On the one hand they took the greatest pains to declare that they did not mean to interfere with the self-government of the colonies, yet on the other hand they asked that the colonies should have a share in Imperial power. No mention was made of being taxed for this share, and he had never yet seen it explained how the colonies were to be taxed by a federal Parliament, and yet maintain their self-government. But unless the colonies paid their share of Imperial taxation, they had no right to a share of Imperial power. He thought the better plan would be to pursue the line of hastening slowly and leading up rather to the necessity of executive concert than of new legislative powers and rule. In conclusion, he might say that it was a great pleasure to be able to say a word in support of the views advanced by Mr. Gorst, for many years ago he was united with him in a policy towards the native race of New Zealand which, if Mr. Gorst's views had been allowed to be carried out, would have saved an immense amount of suffering and trouble in New Zealand, and have probably preserved that splendid native race.

Lord Alfred S. Churchill thought the subject under discussion was one of signal importance to the interests of the country, as well as the colonies. At the present time, federation existed in sentiment, and the question was how legislative sanction could be given to that sentiment. He thought that the representation of the colonies in Imperial Parliament would be best obtained not by means of direct delegation from the colonies, but by gentlemen such as Mr. Gorst and Mr. Alexander McArthur, who had the interest of the colonies at heart, being returned to Parliament as there presentatives of British constituencies. His own idea was that colonists in Parliament would occupy a false position, as they would be voting upon questions of taxation in which they themselves bore no share. There might be an Imperial Colonial Federal Council, which could approach the Government and demand explanation upon colonial policy affecting their interests. He was sure every one who had visited the colonies must have been struck with the intense loyalty shown towards the mother country, and he thought it was only where they united together for the general defence of the colonies, and for the defence of the mother country, that there was any necessity for federation.

Mr. F. Young remarked that he had never advocated the representation of the colonies in Parliament.

Lord Alfred S. Churchill said no doubt he had misunderstood the remarks of Mr. Young.

The Hon. S. A. Joseph (member of the Legislative Council of New South Wales) said that, having resided in the colonies for 40 years, and having the honour to be a humble member of the Legislative Council of New South Wales, he might perhaps be permitted to express his obligation to Mr. Gorst for the able paper which he had read, and also on behalf of the colonies to the Chairman for having ventilated a question of such great importance both to the mother country and to the colonies. One great advantage of having this question discussed was that it held out an invitation to the colonies themselves to assume a position which they in their own mind had never lost. It was quite a mistake to think that there was ever a feeling on the part of the Australian colonies for disintegration from the Empire. No portion of

her Majesty's subjects were more loyal than the Australian colonists. Imperial federation was already a fact, from the circumstances that had already occurred by the offer and acceptance of the New South Wales contingent at the Soudan. It was futile, with the time at their disposal that evening, to attempt to discuss any particular method, or to give an opinion on any particular form which had been so ably suggested by Mr. Gorst. The great benefit which would accrue, would no doubt be that the colonies would feel that they were now recognised. Some years ago it was the fashion to look upon colonists, not as Britons residing in a different part of the Empire, but almost as foreigners and strangers, though he was pleased to know that that feeling of estrangement had never existed in the minds of the colonists. The affection of the child for the parent had never wavered, though the affection of the parent for the child had frequently been of a very doubtful character. It was no use endeavouring to hurry matters, or to attempt to coerce the colonies by any suggestion of legislation in this country; the colonies have proved that they know how to govern themselves, as was shown by the progress which they had made, and therefore the better plan would be to remain quiet for some time to come, and to receive suggestions from the colonies themselves upon these points. The basis of the system had been thrown out, and no doubt the matter would now be taken up with the aid of suggestions from the colonies, and would ultimately develop into the great federation which all so earnestly desired.

Mr. H. Liggins thought it was to be regretted that no mention had been made in the paper of the old colonies, which for 200 years had been the brightest gems in the British crown. The new colonies having asserted their right to be independent, and to govern themselves, had been looked after, but such places as Antigua had been utterly neglected, though the inhabitants were most loyal. What was required was some central office in London, where all colonists might meet, talk over colonial affairs, and so act with more force and power than possibly any individual could do, however great a colony represented; because there was always a tendency to believe that an individual had crotchets and views of his own. At the present time, the West India Islands were sending their produce to the United States on account of the sugar bounty, and for the last six weeks not a single ship had arrived in England from Antigua; and if this state of things was allowed to go on, it would not be long before England lost some of her most valuable islands. He thought it a curious thing they should have met that evening to talk about the federation of the Empire, when they were doing all they possibly could to cut off from England some of her oldest and best islands.

Mr. K. B. Murray (secretary of the London Chamber of Commerce) considered that no hard and scheme should be proposed on this side of the water. Federation undoubtedly meant taxation, and the first step to be taken was, that strong personal opinion should be brought to bear upon the Government, to induce them to consult the colonies as to whether they were prepared for federation, and to ask them for any suggestions which they might have to make upon the subject, because, however perfect a scheme might be drawn up, it would be subject to modification at the instance of different colonies before adoption. It would be difficult for England to take the initiative in the matter, as federation meant taxation; and, therefore, as personal opinion was ripening upon the matter, he hoped one result of that discussion would be that the Colonial-office would feel that the time had come for asking the colonies to express their views upon the subject.

Mr. Geo. W. Rusden agreed that it was wise to ask the colonies to offer suggestions as to the federation of the Empire. This was what the Imperial Federation League Committee had already done. As to the difficulty of combining various States, which had been referred to in different articles written upon the subject, he thought it was answered by the fact that within the last few years the great Empire of Germany had been founded. That was a case in which one great Power had combined with twenty smaller Powers, each retaining its autonomy, and each having proportionate representation in the federal system. Whether the plan would eventually succeed was in the womb of time, but to say that it was impossible, when it was now in progress in Germany, and to hint that Englishmen could not do what the Germans had done, was a most unsatisfactory way of dealing with the question. Mr. Gorst had stated that so far as the army expenditure was concerned, no great alterations were necessary, but if we were to have an army or navy, it must be under such a control and discipline as not to depend on the impulse of the moment. It should not be forgotten that the enthusiasm of the colonies which had brought about the offer of troops, and procured the hearty applause of everyone, had been brought about by the sublime and heroic character of Gordon; and this enthusiasm on behalf of a great man must not be mistaken for a permanent concert that could always be relied upon. The permanence of the loyalty of the colonies could not be doubted, but military service must be regulated under the operation of discipline and law.

Mr. Alexander McArthur, M.P., hoped it would not go forth from that meeting that the loyalty of the colonists was evanescent, and could only be relied upon under circumstances alluded to by the last speaker. Having resided for many years in one of the colonies, he had always found the greatest loyalty manifested, not only in times of prosperity, but in times of adversity, as was instanced during the Crimean War, and the cotton famine, when large

sums were raised. No doubt sympathy with Gordon had something to do with the offer of troops, but he was quite sure that the feeling of enthusiasm was so great, that England might always depend upon the assistance of her colonies in time of danger.

Dr. R. J. Mann, F.R.C.S., said that he was particularly anxious, in connection with the subject which was now before the meeting, to draw attention to the deservedly well-known lectures of the Regius Professor of Modern History in the University of Cambridge on the Expansion of England, which were published by Macmillan during the year 1883, and which were really a most masterly statement from the historian's point of view of the arguments urged in his paper by Mr. Gorst. Professor Seeley's contention in those lectures is that the day has come when we must cease to think of England as an island of 120,000 square miles, and a population of thirty odd millions, off the north-western coasts of Europe, ripening its fruit in the form of generations of men, which are allowed to drop off from the parent tree as they ripen, and to form new colonial communities, scattered over the earth. The England of to-day is a great homogeneous people, one in blood, language, religion, and laws, spreading itself by its inherent and vigorous vitality over a boundless space, and still retaining its cohesion as a State by its identity throughout its expansion in blood, language, religion, and laws. The dropping of the fruit from the parent tree belonged only to the day of the old colonial system, when the colonies were treated as public estates, of which the profits were to be secured to the population of the mother country. But that day is gone, and it is now recognised that if the colonies of a nation like England are not the possessions of England, then the only alternative must be that they are a part of England. Small States cannot exist in the history of the world, unless all other States by which they are surmounted are small like themselves. The tendency of civilisation at the present day is, that healthy States shall be large; that an organisation shall be arrived at in thriving communities, by which the whole force of the Empire community shall be made available for self-preservation and defence in time of war. Professor Seeley insists that England's own children on the further side of the Atlantic, the fruit that did fall off over ripe from the parent stem in the old ill-omened days of mismanagement, have shown by the actual progress of events the possibility of such an organisation. Professor Seeley asks a question which comes with exceeding force and pertinence just at the present time. Russia is even now pressing somewhat heavily upon Central Europe, and, our own statesmen would not be disinclined to add, upon Central Asia, too, with a population of eighty millions, but in fifty years that population will be one hundred and sixty millions, and will possibly then be equal in intelligence and organisation to Germany, with railways made, the people educated, and the government settled on a solid basis—and what will the pressure be then? Is England not called upon at the present moment to weigh, whilst there is yet time, what she herself, in her 120,000 square miles of sea-girt territory, should do in the face of this outlook? Professor Seeley contends that the issue which is before her is, whether she will not so order her affairs as in that future age to be on a level with the greatest of the great States of that advanced day, or whether she will then be on a level with such a European power, as looks back, as Spain does, to the great days when she pretended to be a world State. A small State, as Professor Seeley says, is one thing among small States; but a small State among large States is quite another affair. This, according to the Professor of Modern History at Cambridge, is a question which the sea-girt isle is called upon at the present time to entertain in the councils of its statecraft. The paper which is before the Society is one form of the answer which arises in the forecasts of her statesmen. The federation of the Empire, through the organisation of its world-wide colonial offshoots, is no doubt, the "Expansion of England" contemplated by Professor Seeley.

The Chairman thought the prevailing opinion was that they should not be over-hasty in attempting to realise the feeling existing in England and the colonies for a permanent union. He agreed with that most cheerfully, because he thought the progress which had been made within the last year or two was far greater than was imagined. The idea that the colonies as they grew more powerful must leave England was now pretty nearly dispelled, because it was seen that the colonies, although they were increasing in power and population quicker than it was thought they could do, were prepared to stick by England instead of leaving her. The offers of assistance made by them were beginning to have the strongest possible influence, not only on public opinion, but upon the Government; and he ventured to say, there was now no colonial minister of any Government that would not take counsel with the representatives of self-constituted colonies upon matters that deeply interested them. That being so, they need not be over anxious to have a detailed plan brought forward. What was the position of affairs? England, it was true, had a large population, but it was no match for the enormous collections of armed men on the continent, and it had a work to perform such as no other nation ever had since the world began, of an Empire to protect and maintain. There were 35 millions in England to do this, and in the colonies there were 10 million people as energetic as ourselves—if he might say so—almost more energetic, as they were our own children sent out, and put into circumstances in which they had been obliged to show energy, willing to help us to do this work, and we should be very foolish if this help was not accepted. It was impossible to have any meeting on any public

matter in which we could entirely get rid of the feelings of the day, and of what might be coming over the country. It was possible that the power of England might be strained to its fullest extent in the next few months, or year or two, and for his own part, he felt he could do what little he could with greater strength, and with greater hopefulness, knowing we had the assistance of our colonial fellow-subjects. Now, under what organisation could this be obtained? Without saying what should be the ultimate form of organisation, they had to deal with these facts, that they had an Imperial Government, and Governments of Canada and of different Australasian colonies, and it was at present mainly by combination of the different Governments that they could hope for this organisation. Sir Dillon Bell had stated that expenditure for a common purpose would imply Imperial taxation, but, for his own part, he (the Chairman) did not think there would be an objection on the part of the colonies to give their quota to the Imperial expenditure, which might be found necessary, but the probability was, that for a long time to come the quota might be better raised by means of their own taxation than by an Imperial Parliament. No doubt the Colonial Governments would acknowledge that the Government of the mother country must lead them, but still, they ought to be asked for help, and if what was proposed to be done was placed before them, the requisite assistance would be forthcoming. It was not now the time to decide whether the form of federation should be a federal Parliament or not; eventually it might be so, and if it did become so, it would be because, after there had been this combination of the Governments for some time, their constituents would find this plan the most convenient. If it be not the more convenient way, then that would not be the ultimate form of federation. The world had not exhausted its plans of realising an idea. One difficulty, no doubt, was in the distance between England and the colonies, but he had sufficient belief in science to know that the obstacle was not insuperable. Still it would be foolish to deny that this fact did not make the circumstances different from the case of contiguous countries. It was quite possible that this difficulty might apply hereafter more to Parliament than it would to a combination of Governments meeting together in London, for this reason that representatives, in order to carry out the principle of a representative assembly, ought to be in constant personal communication with those whom they represented. That was a difficulty which could not easily be got over by the telegraph wire, or by letters which took five weeks in transmission. While not agreeing with every word of the paper, still he thought it was one which would set them thinking, and those who were anxious to arrive at federation would study it with great advantage. As to the remarks made by Mr. Liggins, he could not help admitting that the West Indian colonies had a very strong case indeed. In conclusion, he begged to propose a hearty vote of thanks to Mr. Gorst for his valuable paper.

The resolution having been passed unanimously,

Mr. GORST said he hoped the paper which he had the honour of reading would be the means of promoting thought and bringing about a proper conclusion upon the subject.

INDIAN SECTION.

Friday, May 1, 1885: Sir T. DOUGLAS FORSYTH, K.C.S.I., C.B., in the chair.

[This meeting was held in the lower room of Exeter-hall.]

The lecture was on—

HERAT.

By PROFESSOR ARMINIUS VAMBERY.

To speak to-day about Herat, in the face of the numerous and important literary manifestations called forth by the keen interest felt in the subject, is, to say the least of it, an undertaking as hazardous as a visit to that city would have proved a few years ago. I cannot, therefore, offer you much that is novel; and if, nevertheless, I come before you with a lecture on Herat, I do so actuated by the hope of being able to find, after all, a thing or two in my experience, derived from personal observation, which may claim your interest under the present circumstances. In Herat I passed six weeks, and sad weeks they were. Without money or sympathy, and without any hope of speedy relief, I spent many, many hours in my cell in the dilapidated caravansary, pondering on the importance of that city, and its past and future. Since that time I have been frequently taken back to the same spot by my theoretical studies. On my return to Europe, I found that the English politicians of that day were strongly inclined towards optimism, and disposed to dispute with me about the importance of Herat, and I consequently published, in 1869, an essay, entitled "Herat and the Central-Asiatic Question," in which I stoutly maintained the claim of Herat to the title of the "Gate of India." Sixteen years have passed since. The importance of Herat continued to be looked upon as an empty phrase for some time afterwards, until at last, in our own days, the conviction has forced itself upon all mankind, that Alexander the Great, who founded that city in 327 B.C., was not so bad a politician after all; and

that the subsequent conquerors of India were only obeying the logic of facts in considering the possession of that place as a *sine quâ non* of their success in the south.

Herat is in truth, for a variety of reasons, a place of unusual importance, and amongst them are the agricultural, commercial, ethnic, and strategic advantages possessed by it, which I shall proceed to point out. Whilst I was still in the desert with my companions, to the north of the Paropamisus Mountains, they were never tired of repeating to me:—"Have but patience! We are nearing the blessed land; we are going to Herat. There the bread is whiter than the moon, the water sweeter than sugar. You can get there a pot of cream for a farthing, the roast lamb is deliciously savoury, and the most exquisite varieties of fruit can be got for a mere trifle." I arrived in Herat during the autumn, just after the city had passed through a siege of three years. The entire place was a shocking heap of ruins, the environs had been despoiled of all the trees, and yet for all that, when I ventured into the more secluded valleys, and saw and tasted of the rich variety of the products to be found there, I could not help marvelling at the wonderful productiveness of the soil. I discovered that the statements of the geographers of antiquity were by no means exaggerated, and that the glowing accounts of my fellow travellers were strictly true. The soil of Herat is of incredible fertility, and, with the exception of the cultivated oasis in the territory of Zerefshan, there is not another spot in the whole of the Asiatic world, between Siberia and India, which could vie for productiveness with those valleys of the Paropamisus. The wheat ripens in June, and ranks in quality with the so-called Jerusalem wheat of Khiva. The grapes are much more palatable than the celebrated kinds from Bokhara, and superior even to the Tchansh grapes from the environs of Smyrna. The pears and apples are better than those so highly prized in Asia, known as Nathenzians, and the mutton much more savoury than that of Shiraz and Karaman, which is saying a great deal. The inhabitants of Herat have good wool in abundance for the textiles required for their raiment, wood for their buildings, and a great variety of minerals which are only awaiting exploitation. They not only have enough for themselves, but they are also supplying the surrounding country. Thus has the rice of Herat always been one of the chief articles of food of the Turcomans of Merv, and the Hezares in the East; whilst the fabrics of Herat, such as carpets, furs, and different varieties of leather, were being exported by them far and wide. I must make, here, particular mention of the fact that not only in my time, or during this and the preceding century, has Herat been a ruin; but ever since the decline of the Timurides, Herat became the bone of contention among the Persians, Afghans, Usbegs, Turcomans, and Hezares. Peace but rarely dwelt in its precincts, and yet a few years of rest would usually suffice to heal the wounds inflicted upon it, and to restore this fertile oasis to its former splendour.

Herat possesses, in fact, the main requisites for a flourishing agriculture. The climate is temperate, and the hottest days are followed by cool evenings and refreshing dews. Of water, that most essential element, there is abundance. There are, first of all, the two principal rivers, the Murghab and the Heri Rud, both of which run in a north-western direction towards the Turcoman Steppe, and absorb in their onward course a considerable number of smaller streams and rivulets. The Tinghilab and the Keshefrud empty into the Heri Rud, which flows along the Persian frontier; the Kolari and the Kushk empty into the Murghab, the latter river having for its tributaries the Magor and Kizil-Bulak, besides many brooks. Such a great abundance of water within a territory relatively small cannot be met with anywhere in Central Asia, Persia, Turkey, and Arabia, and any one familiar with the important part assigned to water by the Asiatic will not be surprised at all to learn that Herat has always been deemed a jewel, the possession of which has been coveted by every conqueror, and, as experience teaches, continues to be coveted to this day. And, indeed, in this very wealth of Herat we must look for an explanation of the fact that the conquerors for the time being succeeded in maintaining their ascendancy only so long as they were able to impress the governors appointed by them with a sense of their power. For no sooner had the central power relaxed than the governors were enabled to extract from the ample revenues of the province sufficient means to conquer their independence. This has been the case at all times; and referring only to the most recent past I will mention that neither Teheran, nor Ispahan, nor Cabul were able to maintain the sovereign rights of the crown in Herat for any length of time. In this way was Shah Kamran, more properly Yar Mohamed Khan, enabled to successfully resist, during the years

following 1840, the Barekzis, and after 1860 a similar success was vouchsafed to the efforts made in that direction by the then ruler, Sultan Ahmed. Nay, we had the self-same experience at quite a recent date in the case of Ayoob Khan; and it very nearly came to pass that Kuddus Khan himself, the appointee of the present Emir of Afghanistan, seized the reins of government, and made Herat independent of Cabul.

The fact that Herat has at all times defied the sovereign rights of its rulers, must not be ascribed to its being remote from the centre of power, but to the wealth of its soil, which not only sufficed to amply meet the expenses of the administration, but furnished besides means for adventurous enterprises.

I shall not attempt to state the income of Herat in figures, for in the entire absence of statistical data to that effect, any such statement would be only illusory; but, on the strength of my personal observations, I feel justified in assuring those who are present that, under a European administration, Herat might develop into a veritable gold mine, meeting not only the expenses of a costly administration, but admitting of the most generous investments in the future. Especially now that the great curse of the land, the so-called Khow-i Turkmen, that is, the dread of the Turcomans, has been removed, and the ravaging flood of the marauding incursions from the North has been dammed up by the position of Russia, a state of things may be brought about in that district such as has never been witnessed nor experienced there before. The Badghis, more particularly, which has been so well described by the masterly pen of Sir Henry Rawlinson, in the April number of the *Nineteenth Century*, has now a chance of flourishing anew, and rendering Herat in good truth the granary of Central Asia. The fields which were lying fallow until now will be resplendent with luxurious vegetation, and I do not exaggerate in asserting that Herat may become a source of revenue ten times as large as it has been hitherto.

You will, therefore, perceive, gentlemen, the importance of Herat from an economic point of view. I shall now address myself to its ethnical conditions, and may remark, in particular, in this connection that the varied populations collected and settled here in the course of history, furnish the best means for the conqueror to gain a foot-hold there, and to found his rule on the firmest basis imaginable. Whilst, on the one hand, the compact mass of Turkeydom is found in the north of the Paropamisus, extending far beyond the right bank of the Oxus, and in the south the bulk of Afghan elements, and the west the unalloyed Irandom are predominating, Herat is inhabited, on the other hand, by ethnical fragments, whose separate interests, national and religious, render a home government impossible, to the same extent that they increase and support the chances of a foreign rule. The aboriginal population is, as is well known, Iranian, and has always been distinguished for its disposition to culture, its peaceableness, its repugnance against military service, and thorough devotion to the Government of the land. To this race belong the Sunnite and Shiite Persians of Herat, the Parsivans, properly Pars Zeban, that is Persian-speaking, in the south as far as Sebzevar and Ferrah, people who are physically classed as East Iranians, and whose wit and civilisation has always struck me as much as those of the modern man of Ispahan or Shiraz. From amongst them have arisen the great minds of Moslem learning in the fifteenth and sixteenth centuries, for the long list of Herat celebrities, glorified by Baber in his memoirs, belongs for the most part to that race. They have always formed the cream of society, but in politics and war they were for ever the hindmost, and willing to accept without reluctance any foreign rule that happened to prevail for the time being. The rest of the population is comprehended under the common appellation of the Tchihar-Aimak, that is, four tribes, a politico-ethnical expression, dating from the time of the Timurides, by which those entirely strange elements were designated, who had been assisting the hosts of the Timurides in their wars against their western and southern neighbours. Regarding the number of these Tchihar-Aimaks, I could glean but little that was positive, nor am I disposed to have much faith in the reliability of the statements made in that direction by the latest informant, the correspondent of the *Times* with the Afghan Frontier Commission. The Djemshidis, on the Kushk and along the Murghab river, are said to have numbered, two centuries ago, as many as sixty thousand families, and are now reduced to not quite six thousand families. The Firuzkuhis, their neighbours to the east, having Kalei-No (New Fort) for their centre, number eleven thousand families. Both are of unmixed Iranian origin, and belong to that fraction of their race which in remote antiquity already had settled in the

mountains, along the borders of the Iranian element, as a sentinel post, for which reason they obtained the collective name of Galtcha, a name which is now applied to the Persian mountaineers in the heighbourhood of Samarcand. Even fewer particulars are known about the Teimenis, who are living in the south, and are for the most part farmers and tradesmen; and about the Timuris we know no more than that they are occupying the border regions between Persia and Herat, and are tributaries now of one, now of the other. The number of the entire population of Herat may be computed to exceed one million—a million of a race physically and mentally strong, divided, as I said before, amongst themselves by antagonistic interests, and noted for their common hate and detestation of the Afghans, as well as Persians, and whose loftiest ideal has always been the independence of Herat. This ideal, however, Herat has been able to grasp until now but rarely, and that for a very short space of time, but the course of great historical events is undergoing a great change in Asia. Herat is standing on the threshold of an extraordinary metamorphosis, and whichever of the European rivals may chance to get possession of it, they will be sure to avail themselves of the favourable circumstances to obtain a firm hold there, and will find an essential support in the above-mentioned Tchihar-Aimaks. The Firuzkuhis, Djemshidis, and Timuris, reared as they are in warfare, may be transformed, at but small expense, into an excellent militia, and trained into becoming a reliable barrier against Afghanistan and Persia in the defence of the borders of the country, whilst, at the same time, under the production of a stable Government, the Parsivans and Tadjiks may develop into becoming powerful agencies of commerce and industry.

The situation of Herat is, in fact, such a one that, in its commercial and strategic importance, it is surpassed by but few cities in Asia. The commerce of India, Sogdia, and China reached the west in ancient times by passing through Herat, along the north of Persia, and through the Caucasus, and continued to follow that route until the incursion of the Mongols, and to some extent even up to a later time. Even during our own century—nay, until quite recently—Herat has been the emporium for tea and indigo on the one hand, and American and English wares, such as cotton fabrics, cloth, trinkets, &c., on the other hand. I myself have witnessed the unpacking and trading of the various articles in the numerous caravanserais, and so extensive had the trade between the north and south become, that the villagers in the near vicinity of Herat earned for the most part their livelihood by the business of transportation. At the time I was there, there were in Kerukh alone eight wealthy kervanbashis, who managed with their numerous camels the transportation between Meshed, Bokhara, and Candahar. The merchant from Lohani and Cabul most likely conveyed his own caravans to Herat, but the merchants of Bokhara and Meshed were compelled to employ the Herat forwarders; and that Herat had always served as a channel of communication between the south, north, and west, is proved by the description given by the historians of the past of the splendour of its bazaars, of which, it is true, there now remain but miserable ruins.

Nature and man have co-operated in establishing the importance of this place. You are well aware of the fact, gentlemen, that all the conquerors of India of bygone days have passed through Herat, have marshalled their armies there, and allowed them to rest at Herat in order to prepare them for the change of temperature in the southern latitudes. To this very day this traditional highway to India is preferred to the route over the Hindoo Koosh and Cabul, not only by armies and caravans, but by solitary travellers such as the pilgrims to Mecca. The pilgrim allows three months for his journey from Herat to Karachi, a long stretch of road frequently deficient in water, and yet he prefers it to the mountain road running more to the east, a road which of all the conquerors of India was attempted only by Baber and his courageous companions in arms. I wish to call your attention to the additional circumstance that almost every conqueror of India, advancing from the north to the south, had secured the possession of Merv and the oasis on the lower course of the Murghab, before he proceeded to attack Herat. Timur did not invest the city on the Heri Rud until he had reduced the Turcomans about Merv, and placed them under his banners. The same thing was done by Sheibani, the prince of the Usbegs, in the beginning of the 16th century, when he first took Merv and subsequently Herat. Nadir Shah, too, has proceeded in the same manner; and it is quite remarkable that Russia, which is also advancing from the north to the south, is pursuing the identical policy,

planting her banner on the ruins of Merv, after having subjected the three Turkestan khanates, and reduced the Turcomans; and, in order to be quite consistent in acting up to the example set by a Timur and Sheibani, she now approaches the frontiers of Herat with the view, as may be imagined, of obtaining possession of the city on the Heri Rud, and getting into her hands the important central point which is indispensable to the further pursuit of her ulterior plans.

But as this event has been instrumental in bringing about the recent conflict between England and Russia, and I am fully determined not to discuss politics in this hall, I shall abstain from speaking here about Russian claims to the Penjdeh, and the intended frontier line from the Zulficar Pass over Akrobat, extending south of Penjdeh. I shall, instead, advert to the fact that as far as historical memory goes back, the district of Badghis has always formed a component part of the province of Herat, and was not at any time presumed to be a part of either Merv, Meshed, or Nishapur respectively. Even during the period of splendour of Herat, under Shahrukh Mirza and Hussein Mirza, Badghis had a governor of its own, entirely independent of Merv and Meshed, and the same was the case under the Sevfides, who, as is known, followed the Timurides and Usbegs in their rule. The conditions of such a frontier lie in the nature of things, for there, where Badghis ceases begin the sand regions of the Turcoman Steppe. Nature herself has drawn here the precise line of demarcation, and Penjdeh, as well as Akrobat, being situated within the lines of the cultivated soil of the north-western offshoots of the Paropamisus, they belong to the Badghis, and are parts of the district of Herat—such parts as are, so to say, the keys of the routes along which the main highway can be reached without any trouble. The acquisition of Herat is only a question of time—and that of a very short time—with the Power that happens to get hold of the said points, for considering the disfavour with which the Tchihar-Aimaks and Hezares are viewing the Afghan *régime*, it will be an easy matter for a well-regulated European Power to conciliate the sympathy of these populations, and sustained by their goodwill, to obtain possession of Herat.

The preceding remarks have abundantly shown the importance of the possession of Herat to a European State, and the excitement provoked by the approach of Russia to that city is, therefore, tolerably justified. Starting from this point of view, and admitting that Herat, under all circumstances, is deservedly called the "Key to India," or the "Gate of India," it is readily conceivable that every patriotic Englishman who cherishes in his heart the future of the Indian Empire, and the position of Great Britain as a Power depending upon it, is apt to perceive in the advance of Russia towards that part of Afghanistan an imminent danger to the interests of his country. We, on the Continent, however, are judging of this matter, for self-evident reasons, from quite a different standpoint. As strictly objective spectators, we are likely to be less concerned in the national interests of England or Russia. We keep before our eyes the loftier aim of the mission of European culture, and in pursuit of this object the majority of the thinking Europeans feel compelled to take sides with England, because that country has ever been the seat of liberal thought, the cradle of exalted ideas, the source of the glorious light of civilisation, and has with much greater success unfurled the banner of western culture in Asia than Russia, which is despotic to her very core, and thoroughly leavened with Asiatism. Envy and rivalry and political shortsightedness may beget temporary exceptions to this general proposition, but taking everything into consideration, European sentiment will never be able to deteriorate so far as to give preference to the civilising efforts of Russia. We are much too fond of peace, this most highly valued jewel of our 19th century, to sympathise with that power which, constantly brooding over schemes of aggression and aggrandisement, mischievously flourishes the brand of war, and is enacting ravages in neighbouring countries as a sop to pacify the revolutionary elements in its own country. Russia is as aggressive and warlike in Asia as England is conspicuous for her conservatism and fondness of peace—a fondness which makes her even dread to take the necessary precautions for the protection of her frontiers. In calling attention, during the past decades, in the Continental and English press, in periodical writings and books, to the dangers of Russia's advance towards India, I certainly was not actuated by any personal grudge or settled dislike of Russia, and least of all by any desire to fan the flames of war. Wars are the most disgraceful reminders of the dark past, and no thinking man, least of all a man of the pen, will advocate them. We still believe, at this very day, that Russia and

England could peaceably dwell side by side in Asia, severally pursuing the noble object of their civilising mission, if both were inspired by the like sincere desire of doing so. Russia, as the heir of the Turanian conquerors of the north, has already united to-day under her sceptre almost all the nations and tribes of the Ural-Altaic origin. She is adequate to the task of civilising these nations and tribes, who will be enabled, by means of the Russian civilisation, to enter most easily upon the path of a better state of things. Russia is a veritable blessing to the Ural-Altaians, but she should now be satisfied. She ought to and can draw a boundary line to the region of its culture, and must not stretch her hands after the classic soil of Aryan culture. These two worlds meet at the Oxus, and the southern line of the Turcoman Steppe. The attack of Herat has, therefore, been justly looked upon as an encroachment upon the southern, that is, the Arian region of culture, and this latest Russian aggression is offensive, not only to Englishmen, but likewise to every friend of Western culture. The forcible expression of "Hands off" would be in the right place here. For, in the first place, it would be a great pity if India, which has been successively brought, in the course of a century, into the path of European civilisation, should now be subjected to fresh civilising experiments, and the minds between the Suleiman range and Cape Comorin, which had been gradually calming down, should be excited anew by fresh revolutions. Nor can it be, in the second place, a matter of indifference to any friend of enlightenment and liberal institutions, if the banner which is still proudly floating over Great Britain should be lowered by jeopardising or losing the Indian possessions, and England, the asylum of liberty and right, be degraded into a State of the second or third rank. I repeat it, this is the view taken by the majority of the unprejudiced thinkers of Europe, but, unfortunately, views of a different kind are prevailing with certain circles that decide on these matters, and Russia in particular does not wait to know anything about the cultural boundary mentioned before, and is anxious to pursue the aggressions to the south which she has carried on for centuries. Her attack of Herat is the most telling proof of this, and it only remains to be seen how patriotic England will behave in the face of this attack. Nobody will dispute to-day the fact of Herat's being the gate of India, and the immediate future will inform us whether the enemy shall be allowed to enter or be driven back with manly resistance.

The CHAIRMAN then moved a vote of thanks to Professsor Vambéry, and in doing so, said the importance of hearing the opinions and views of one who had lived in Central Asia, and who was thoroughly acquainted with the manners and customs and politics of the country at the present crisis, was of the utmost importance. From his own experiences in Central Asia, he could bear testimony to the fact that Professor Vambéry had not in the slightest degree exaggerated his description. Whilst he had very properly abtained from all discussion of politics, there was one most important fact which he had mentioned, and that was that, from the earliest history, the district of Badghiz had always formed a portion of the province of Herat, and had not at any time been considered to form a portion of the province of Merv or Meshed. This was a matter of the utmost importance. He could bear personal testimony to this fact, that Badghiz and Penjdeh belonged to Herat, because when he was about to start on his mission to Yarkund, the Prime Minister of the Ameer of Cabul, in discussing the whole line which he was to traverse on his return, particularly mentioned Penjdeh as being one of the spots in Afghanistan which he would have to visit. Having adverted to the singular loyalty manifested by the natives of India towards this country as an all-sufficient answer to the statements made that they were desirous of Russian rule, the Chairman, in conclusion, remarked that after all that they had heard to-night, and after what had been put forward by able experts as to the enormous importance of Herat, both strategically and politically, owing to its position and unrivalled resources, it was difficult to suppress a feeling of astonishment at the conduct of certain writers calling themselves Englishmen, who were not only insensible to the dangers which would threaten our Empire if Herat fell into the hands of a great Power hostile to our interest in India, but who were so devoid of all patriotism that they took pleasure in distorting facts and misleading the public. They put forward everything that they thought could discredit our own officers, and warmly espouse the cause of our antagonists. The burning question of the day was not merely who struck the first blow, or whether the boundary line should be drawn a few miles to the north or south, but "What business has Russia there at all, and what is her real object?" In 1869 and 1872 the Russian Government admitted that they did not care about what was happening on the Afghan side because they were separated from Afghanistan by a vast desert of sand, which formed a natural boundary, and across which they had no intention of going. What, then, was her object in now crossing these deserts and entering the border of an entirely separate kingdom? They boldly told them

their object was India, and yet while they did so we made every excuse for them, and declared they did not mean what they said. This country now ought to say to Russia, with inflexible resolution, "Thus far you have gone, but you shall go no farther. If India be your object, you must first vanquish England, but we will spend our last shilling and our last drop of blood before we let you have it." But he was afraid he was transgressing the rules—and would therefore retract and apologise, and simply now ask them to accord the vote of thanks to the distinguished lecturer.

Lord HOUGHTON said that, as one who for twenty years had enjoyed intimate relations with M. Vambéry, and as trustee of the Royal Geographical Society, he was delighted to welcome him to England again. Allowing to the very utmost all that one-sided politicians or philosophers might have said with regard to the civilising influence of Russian conquest in the East, they would draw the conclusion from what M. Vambéry had told them, that Herat was not one of those parts of the world which required, or could accept with willingness or advantage, such civilisation as Russia could give.

Professor VAMBERY, in acknowledging the vote of thanks, referred to the heartiness of the welcome he had received in Yorkshire, and declared that, after all the bitterness of feeling he had endured through the twenty years he had been writing on this subject, he was amply rewarded by the reception he had met with in this country. He was rejoiced to find that the indifference which had hitherto encouraged Russia to proceed southward had at last disappeared. Whether this country went to war or not, he was sure that Russia would think twice before she again went on towards the south.

TWENTIETH ORDINARY MEETING.

Wednesday, May 6th, 1885; Professor W. GRYLLS ADAMS, M.A., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Bottomley, George, Uttoxeter-road, Derby.
Brigg, William, Bank-side, Teddington.
Gibbs, Henry James, Arrandale, Mount Ephraim-road, Streatham, S.W.
Gower, Frederic Allen, 44, Rue François I., Paris.
Smale, Morton, 89, Seymour-street, Hyde-park, W.
Thimm, Carl Albert, 54, Torrington-square, W.C.
Vawser, Robert, 17, Cooper-street, Manchester.
Want, Randolph C., M.A., 13, Sumner-place, Onslow-square, S.W.

The following candidates were balloted for and duly elected members of the Society:—

H.R.H. Prince Albert Victor of Wales, K.G., Marlborough-house, S.W
Garcke, Emile, Anglo-American Brush Electric Light Corporation, Belvedere-road, Lambeth, S.E.
Gaussen, David, Broughton-hall, Lechlade, and 8, Craven-hill, W.
Hake, George Gordon, 12, Portland-place, Hammersmith-road, W.
Schwann, Frederick, Oakfield, Wimbledon.
Scott, F. Walter, Woodcliffe-house, Burgess-hill, N.W.
Smith, Charles Ridley, 32, Nicholas-lane, E.C.
Smith, J. Fisher, 89, Piccadilly, W.
Tripplin, Julien, 5, Bartlett's-buildings, E.C.
Wilson, Francis, 109, Long-acre, W.C.

The paper read was—

NOBERT'S RULING MACHINE.

By JOHN MAYALL, JUN., F.R.M.S., F.Z.S.

The ruling machine of the late Herr F. A. Nobert, which I have the honour to bring to your notice this evening, in so far as its special applications for the production of microscopical test-plates, interference-plates, and diffraction gratings are concerned, must, I think, be regarded as of essentially original design. I have not been able to connect its origin with any ruling machine of anterior date, though I have searched somewhat diligently through sundry journals and transactions of various societies, and have had the assistance of Dr. Hugo Schröder, who is well known to have taken much interest in fine mechanism, and more especially in Nobert's work, during the past thirty years, and who has sought to inform himself from every available source.

I may at once state that, without the co-operation of Dr. Schröder, my notes on Nobert's machine would have been far less complete than they are; and I must, therefore, at the outset, acknowledge my obligations to him for many explanations and conjectures, without which several important points of the construction would have baffled me.

I should also premise that Herr Nobert was extremely reticent as to the methods he employed in the production of his rulings. So far as I have been able to learn, he did not fully communicate his methods to any one competent to convey the information to others. The description, therefore, which I shall present to your notice will consist almost wholly of notes made by Dr. Schröder and myself, after minutely examining every part of the machine, together with a few gleanings from the memorandum-book in which Herr Nobert jotted down, from time to time, fragmentary

observations and data, hardly to be understood by any one but himself.

But, first, for the information of those of my hearers who may never have heard of Nobert's rulings, permit me to make a few introductory observations as to the meaning and purpose of fine rulings, so as to lead up gradually to a comprehension of the problems which Nobert set himself to solve, and the methods he adopted towards their solution. In this way I hope not to have to draw too much on your imaginations when I come to speak of the difficulties of his work, of the mechanical resources he developed in grappling with these difficulties, and of the success he attained.

I have here an ivory scale divided to hundredths of an inch, the divisions of which are filled with wax and graphite, so that the lines appear black, and the interspaces white. Everyone present, who has normally good sight, will have no difficulty in resolving the lines, that is, in seeing by the unaided eye the spaces between the consecutive lines, provided the scale be suitably illuminated. Those among you who have not yet tried the experiments, will be surprised to observe how much more perceptible are the lines if illuminated by a condenser. If ivory scales were accurately ruled, so that each line was equal in breadth to the interspace, some of you would resolve, without much difficulty, lines as high as 150 to 200 to the inch with the unaided eye, whilst here and there exceptionally powerful sight would resolve lines even closer. These figures would be slightly augmented if the lines were ruled on glass, and viewed under the most favourable circumstances by transmitted light. I have met with one instance where lines on glass, slightly closer than 250 to the inch, were resolved by the unaided eye.

I would here call your attention to a point which has frequently produced misunderstandings in discussions relating to the possibility of perceiving fine lines. In referring to the resolution of lines, I mean the capacity of separating, in vision, adjacent lines, that is, the recognition of the interspace. This resolution must not be confounded with the capacity of mere perception of a line or point, that is, the recognition of the *minimum visibile*. Many experiments have been devised with a view to determining the conditions and limits under which the eye resolves lines or points of interspace of a given fineness, but the problem has not been absolutely solved, so far as I am aware. Neither have the conditions or limits under which the eye may reach the *minimum visibile*—the perception of a line, or point, in an otherwise homogeneous field of view—been worked out with any approach to demonstration, for it still remains to be explained under what optical and physiological laws we are able to perceive stars which do not subtend an appreciable angle, even to our finest optical and measuring appliances.

I have here a series of stage-micrometer rulings on glass, commencing with fifty to the inch, and progressing to 10,000 to the inch. They probably belonged formerly to the possessor of a microscope in the days when the measurements of objects were generally made by direct inspection and comparison under the microscope, and before the introduction of the modern methods of measuring by screw-micrometers, either on the stage or in the eye-piece. These old rulings are of fair quality, and I show them with a view of fixing in your minds a stand-point from which the fineness of Nobert's rulings may be appreciated.

Early in the century, Frauenhofer gave a great impetus to fine rulings by the production of his diffraction gratings, in which he aimed at and achieved a standard of accuracy in division and perfect similarity as to depth, breadth, and symmetry of angles of the furrows, such as had never before been formulated. He succeeded in ruling lines much closer than those contained on the highest of the series of micrometers I exhibit—as high, indeed, as 30,000 to the Paris inch; but, according to Sir John Herschel,* these fine lines were not sufficiently accurate to produce pure spectra, nor could he go beyond 8,200 lines to the inch when they were submitted to this most searching test of accuracy. Sir David Brewster† mentions that Barton produced rulings on steel up to 10,000 to the inch, which gave excellent spectra in his hands. Some of you probably have seen the so-called "Barton's buttons," which were stamped from his ruled steel dies.

About the year 1823, a great improvement in the construction of compound refracting microscopes was initiated by Seliigues,‡ who applied achromatism to the objectives, by which, in the course of a few years, the instrument was so much advanced that there was considerable difficulty in discovering test-objects of a nature suitable to serve as

* Art. "Light," "Encyclopædia Metropolitana," p. 489.
† "Optics," "Lardner's Cyclopædia," p. 120.
‡ Quekett's "Treatise on the Microscope," 3rd ed. (1855), p. 40.

standards for estimating the quality of the newer objectives, and especially for testing the value of each increase of aperture as successively attained.

Herr Nobert appears early in life to have been interested in the progress of the construction of the achromatic refracting microscope. The difficulty attending the testing of the increased apertures, doubtless, led him to devote his attention to the production of fine rulings, whilst the publication of Frauenhofer's experiments with diffraction gratings would likewise stimulate him to improve upon the results obtained with Frauenhofer's rulings, both in the direction of fineness and accuracy.

For some time previous to 1845, Herr Nobert, then resident in Greifswald, appears to have been engaged in designing and constructing the ruling machine which I here exhibit, for in that year he succeeded in ruling a test-plate with 10 bands of lines, which, commencing with $\frac{1}{1000}$th of a Paris line, and continuing in geometrical progression, ended with lines of $\frac{1}{4000}$th of a Paris line (from $\frac{1}{11261}$ to $\frac{1}{45045}$ of an English inch). You will observe that Nobert's coarsest lines ranged somewhat finer than the finest of the set of micrometer-plates I have referred to as representing the fine rulings before the days of the achromatic refracting microscope. Each band ruled by Nobert consisted of a number of parallel and equidistant lines at the rate specified, and a blank space, about equal in breadth to the bands, separated the successive bands. These bands of lines were intended as test-objects, to determine the resolving power of microscope-objectives. Herr Nobert mentions (in a MSS. published after his death, but evidently written about 1861) that "the German microscopes of that date resolved the 8th band of that plate, and Amici's the 9th, whilst in the following years, when the plate had become known in England, the decided superiority of English instruments resolved all ten bands."

The immediate effect of Nobert's rulings was to reverse the order of things that had hitherto obtained in microscopy. Before the issue of his test-plate, opticians and microscopists hardly knew where to seek for an object capable of severely testing the resolving power of their newer objectives with increased apertures. But now, at one bound, he went beyond the resolving power of the finest microscopes of the day. And, strange as it may seem, so far-reaching was Nobert's mechanical genius, that the machine of 1845 not only enabled him to produce rulings finer and finer, always beyond the resolving power of the most perfect objectives as successively brought out by the contemporary opticians; but when, in 1869, after most ardent devotion to the task, the eminent microscopist, the late Dr. J. J. Woodward, of the Army Medical Museum, Washington, succeeded in photographing the highest band of the 19-band plate ($\frac{1}{10000}$th of a Paris line = $\frac{1}{112612}$ of an English inch), with Powell and Lealand's water-immersion $\frac{1}{16}$th objective, Nobert immediately outstripped all his previous efforts by ruling a plate with lines twice as fine, that is to say, ranging from $\frac{1}{1000}$th to $\frac{1}{20000}$th of a Paris line (from $\frac{1}{11261}$ to $\frac{1}{225224}$ of an English inch). This last plate was rather a *tour de force*, and will tax the resolving power of the microscopes of the future.

By the courtesy of the Surgeon-General of the United States Army I have received the series of Dr. Woodward's photo-micrographs of Nobert's 19-band plate, and they are here for your inspection.

But I must go back again briefly to earlier dates. About 1850, Mr. Warren De la Rue * made an elaborate series of trials with Nobert's lines, and induced him to add bands of finer lines to his test-plates, so that gradually he arrived at a plate containing 30 bands, beginning at $\frac{1}{1000}$th and reaching $\frac{1}{8000}$th of a Paris line (= $\frac{1}{90090}$ of an English inch). In 1860, Messrs. Sullivant and Wormley † succeeded in counting the lines in the 30th band, whereupon Nobert, wishing to add still finer lines, and yet to diminish the labour of ruling so many bands, re-cast the fractional divisions of the successive bands, still keeping to the Paris line as the unit, resulting in the 19-band plate to which I have already referred. When Dr. Woodward succeeded in photographing and counting all the lines on the 19-band plate, thus furnishing a perfect demonstration that the development of the resolving power of the microscope had unquestionably reached the level of the 19-band plate, Nobert again re-cast the fractional divisions of the successive bands, resulting in the latest 20-band plate, ranging from $\frac{1}{1000}$th to $\frac{1}{20000}$th of a Paris line. Regarding this plate, I may remark that Dr. Woodward did not succeed in photographing any lines beyond the 10th band, which was precisely equivalent to the 19th of the 19-band plate. I take this opportunity, however, of stating that Mr. E. M. Nelson, so well-known

* Quekett's "Treatise on the Microscope," 3rd edition (1855), pp. 511—4.

† American Journal of Sciences and Arts, Jan. 1861.

for his manipulative skill with the microscope, has succeeded in resolving the 11th band ($= \frac{1}{11000}$ of a Paris line $= \frac{1}{123873}$ of an English inch), using the oxy-hydrogen lamp for the illumination in my presence.

You will understand, then, that Herr Nobert devised these fine rulings to serve as test-objects for the resolving power of microscope-objectives. On the supposition that an objective had a given extent of aperture free from aberration, then, according to a certain optical formula, suggested by Frauenhofer, such an objective should resolve consecutive lines of a certain degree of closeness. The bands of lines were graduated in fineness by Nobert, with a view to furnishing an approximately exact measure of the limit of the resolving power of any objective tested upon them. In recent years Frauenhofer's formula has been revised by Helmholtz and Abbe (independently), so that the theoretical limit of resolution has been extended two-fold for every increment of aperture, on the supposition that light of the greatest possible obliquity is employed for the illumination.

I remark *en passant* that the mere resolution of a specially high band seems to have been erroneously regarded by Herr Nobert and others as a sufficient test of the quality of an objective; whereas it can be demonstrated that the fact alone that an objective resolves a given band proves only that the particular zone of aperture which is utilised in such resolution is free from aberration; and this may obtain in an objective in which nearly the whole of the other portion of the aperture is so affected by aberration that the objective, as a whole, must be regarded as of inferior quality.

With reference to the interference-plates and diffraction gratings ruled by Herr Nobert, I cannot speak from personal experience with them. He claimed for them that they were the real tests of the accuracy of his ruling machine, as regards exact equidistance of the divisions, parallelism of the lines, equality in thickness, and symmetry of angles of the actual rulings; and as he had to face many sceptical critics, I think it may fairly be assumed that his claims were admitted, inasmuch as they were not refuted. I shall have to direct your attention to the special means employed by Herr Nobert to secure the strict equidistance of the divisions required for the diffraction gratings, where lines of one Paris inch in length were ruled over a breadth of one Paris inch, at the rate of 1,200 to 12,000 to the Paris inch—that is to say, the whole space was covered by lines of these degrees of fineness. He states that "these gratings show spectra of such perfection, that in the wave-lengths of the Frauenhofer lines, as established by Prof. Listing, even the $\frac{1}{10000000}$ of a millimetre is made apparent;" and that the absolute measure of his divisions was "founded on a standard accurately corresponding with the original Bessel standard-measure made by the distinguished Berlin mechanician, Baumann."

Herr Nobert appears formerly to have held that Frauenhofer's formula based on the constitution of light (to which I have alluded) would present an absolute bar to the resolution of lines finer than $\frac{1}{8000}$ of a Paris line ($\frac{1}{90090}$ to the English inch); Dr. Woodward's photographs, however, disproved this theory to his complete satisfaction. A suggestion was also made by an adverse critic, that possibly the higher bands, which had not been resolved, did not really contain the lines alleged by Nobert; to which Nobert answered by providing an interference-plate* which "proved indirectly ($= \frac{1}{8000}$th of a Paris line $= \frac{1}{90090}$th of an English inch) the existence of all the lines up to 0'''·000125 by the spectra they showed. With this plate was also proved, empirically, the inference from the undulatory theory of the disappearance of the colours, when the distance of the lines is less than the smallest wave-length in the medium used."

Having given you a general view of the meaning and purpose of the fine rulings produced by Herr Nobert, I proceed to the description of the ruling machine itself, and of the methods he probably employed.

The foundation of the machine is a dividing engine, calculated to produce parallel divisions far finer than could be marked by any ruling point yet discovered. The division-plate is about 12 in. in diameter, and has twenty rows of "dots," by means of which two bands of silver imbedded near the circumference have been graduated with extremely fine lines to every five minutes in arc. These graduations are viewed by two compound microscopes, each provided with eye-piece screw-micrometers of special construction. The microscopes can be fixed at various points on the edge of the main iron bed of the machine, so as to check the rotation of the graduations of the division-plate; and the eye-piece screw-micrometers in the microscopes enable the observer to subdivide the graduations by inspection, and to correct the movement of rotation, within very narrow limits. The

* Poggendorff's "Annalen," lxxxv., p. 83.

rotation of the division-plate is effected by a tangent-screw acting upon a worm on the edge of the division-plate. The tangent-screw is controlled by a large milled head, and a graduated drum shows the amount of motion. A screw adjustment is provided, by which the tangent-screw can be disconnected from the division-plate. In order to equalise the pressure of the tangent-screw against the division-plate, it is mounted to swing between conical bearings, and a counterpoise on a lever arm beneath keeps it in contact with the worm. The method employed by Nobert for obtaining the minute divisions of his test-plates was, to utilise the radius of the division-plate as a lever to move the glass plate on which the rulings were made at right angles to the motion of the ruling point. For this purpose, he attached to the centre of the division-plate a bent arm, on which slides a bar faced with silver, having at one end a finely-polished steel point which can be adjusted by a scale and vernier so as to project more or less beyond the centre of the division-plate or axis of rotation. The radius of the division-plate thus becomes the long arm of the lever, whilst the radius of the projection of the polished steel point beyond the axis of rotation forms the short arm, the centre of the division-plate being the fulcrum. The motion of the short arm of the lever is communicated by contact with an agate plate to a polished steel cylinder, adjusted to slide at right angles to the movement of the ruling point in V-shaped bearings of agate. The steel cylinder carries a circular metal table, on which the glass plate to be ruled is fixed by wax and clamps. To diminish the friction of the steel cylinder on the agate bearings, a counterpoise is provided, to lift it on a roller, whilst a weight, attached by a silk cord to one end, keeps the agate plate in perfect contact with the motor steel point. The motion of the lever arms is, of course, in arc, and hence the divisions would not be strictly equidistant unless compensation were made for the difference in length of the arc and its sine; but since the actual space included between the first and last lines of the test-plates hardly exceeds 1-50th inch, this difference would be inappreciable. It may be assumed that Herr Nobert used the arc motion during the process of division only, and that for moving the plate over the spaces of the blank bands between the rulings he utilised the fine screw connected with the agate plate in the steel cylinder, by which a motion of the plate of about $\frac{1}{2000}$ of an inch can easily be effected; in this way he would reduce the total motion of the division-plate in arc to about one-half. It would be possible to increase or decrease the successive divisions of the bands by increasing or decreasing the length of the short arm of the lever; but in view of the risk which such adjustments would involve, it is highly improbable that such a plan was adopted. There are other possible methods of effecting the divisions, all involving risk of large errors; the most probable conjecture is that Herr Nobert used the greatest possible excentricity of the short arm of the lever, so as to utilise the smallest motion in arc required for his subdivisions.

The arrangement for carrying and adjusting the diamond point is specially ingenious. The questions to be solved were—(1) to provide means to adjust a diamond edge to any angle within required limits; (2) to balance it truly so that the weight-pressure for ruling could be perfectly controlled; (3) to raise and lower it strictly in one plane—that is to say, mechanically free from lateral play, so that the consecutive divisions of the ruling depended solely on the motion imparted to the glass plate by the dividing engine; (4) to cause the diamond to oscillate freely in one plane; (5) to control the length of the lines to be ruled; (6) to connect the whole with mechanism to insure an even rate of speed in the ruling movement of the diamond.

These matters have been worked out by Herr Nobert with extraordinary perseverance, as evidenced by the elaboration of the adjustments. I should despair of making myself understood on these points by mere verbal description; I shall, therefore, ask you to inspect the mechanism at the close of my remarks, for, to be understood, such complex adjustments need to be seen "in the flesh."

It would be an easy matter to suggest simplifications and possible improvements in this part of the machine. But it must be noted that Herr Nobert had always to work with very limited means, and under the great disadvantage that he thought it necessary not to disclose his methods of working. Judging the mechanism by the work he did with it, there can be but one feeling among all who are familiar with his ruled test-plates—a feeling of intense admiration for the inventiveness and extraordinary dexterity he brought to bear on the subject under the circumstances.

For the production of diffraction gratings, interference-plates, and micrometers, where the equidistance of the lines would be of extreme

importance, and where the breadth of space covered by the lines is so large that the lever motion in arc would have produced errors in the evenness of the division, Herr Nobert removed the bent arm from the centre of the division-plate, and substituted a vertical cylinder, on which he coiled an extremely thin, flat steel spring, having a hook at the free end. This hook he attached to a stud beneath the polished steel cylinder which carries the glass plate to be ruled under the diamond, and which takes the place of the carrier used for the test-plates. The rotation of the division-plate caused the vertical cylinder in the centre to rotate, coiling the steel spring, and thus, after the manner of a windlass, hauled along the diffraction-plate carrier at right angles to the ruling motion of the diamond.

In a former description of this part of the machine (given at the Royal Microscopical Society) I stated that Nobert probably used the stud and "dots" to divide his diffraction gratings, &c. On further consideration, I find I was in error on this point. Incredible as it may seem, I am now convinced he must have used the micrometer-microscope on the division-plate for every line, although as a matter of fact, some of his diffraction gratings had 12,000 lines upon them. Where such extreme accuracy was needed, he would assuredly adopt the most certain method, which is to work with the division-plate and the micrometer-microscope. Here, indeed, is an example of perseverance. Imagine the task of adjusting the divisions under the micrometer-microscope, winding up the train of wheels, lowering the diamond on the plate, starting the train, watching for a possible vibration in the mercury bath during the actual ruling, which might ruin the scientific value of the plate, then lifting the diamond by the excentric roller preparatory to recommencing the whole operation—12,000 times in succession!

The preparation of the diamond points has long been considered as the grand secret of Nobert's success. Beyond the admission of the bare fact that he did use diamonds, he kept the secret of their preparation. When the machine came into my hands, I expected to be able to explain the preparation of the ruling points immediately by inspection with the microscope; but the matter was far more difficult than I had supposed. My appeal to diamond "experts" brought me face to face with absolute contradictions. There were ten diamonds with the machine. Two of them were technically termed "points," pyra n] fragments of diamond terminating in points. All were agreed that these were untouched by the polishing mill. The other eight diamonds each presented the general form of two faces meeting in an "edge;" the difficulty was to decide whether the faces were in some cases (1) both polished, (2) both cleaved (cleavage-faces unpolished), or (3) one polished and one cleaved. The opinions of the diamond experts could not be reconciled, for in two instances they were wholly opposed, one party affirming that both faces were polished, whilst the other party were equally positive that both faces were due to cleavage alone, and were not polished. Under these circumstances, it appeared to me essential to submit the diamonds to the test of the goniometer, with a view to determining whether the angles of the natural cleavage-planes had been altered, any such alteration being necessarily due to artificial polishing of one or both faces. I thought it would be most satisfactory to ask the assistance of a professional mineralogist, and, therefore, applied to Mr. Lazarus Fletcher, of the Mineralogical Department in the British Museum, who very kindly undertook to examine the diamonds, and measure the angles with Fuess's goniometer. In Mr. Fletcher's opinion the two "points" were untouched by the polishing mill; diamond No. 4 consisted of two cleavage-faces meeting in the edge, and was untouched by the mill; in each of the seven remaining cases, one of the faces meeting in the edge was an untouched cleavage-face, and the other had been polished, and in some cases an additional facet or two developed on that side. The goniometer showed that in the polishing the angles had been altered from the natural cleavage-planes by quantities varying from a few minutes up to about six degrees, and as no two were exactly alike, it might be assumed that, as Mr. Fletcher suggested, "the alteration of the angle is merely an incident of the polishing," and not a condition distinctly aimed at by Herr Nobert. I had previously stated (at the Royal Microscopical Society) that some of the diamonds appeared to have two polished faces meeting in an edge. On closer examination in Mr. Fletcher's presence, I found that certain striations on the faces, which I had regarded as imperfectly polished, were more probably untouched, and hence I have given my adhesion unreservedly to his judgment.

As to the mode of preparing the ruling diamonds adopted by Herr Nobert, I have no record, save the diamonds themselves; the matter can only be decided by conjecture.

After various consultations with diamond experts, I have come to the conclusion that diamonds exhibiting under the microscope precisely the character of the seven "edges" to which I have referred, could be prepared from the fragments of gem diamonds met with at any diamond cleaver's. The cleaver would select a fragment which would admit of two faces being cleaved to an edge of about 1-16th or 1-20th inch in length; one of these faces should be perfectly polished on the mill, as nearly as might be parallel with the cleavage-face; the other face should then be cleaved again parallel to its former cleavage, so as to remove the edge, which would probably have been somewhat rounded by the mill, thus furnishing a new and probably sharper edge—a clean fractured face meeting the plane polished face. The diamond should then be mounted in soft metal, in a notch at the end of a piece of brass wire, by means of the blowpipe.

Nobert's original rulings appear to have been made on artificially polished surfaces. Later on, he experimented with thin cover-glass, ruling on the natural or melted surface. More recently, Dr. Schröder called his attention to a kind of glass technically termed "mild" glass, and instructed him in a method of polishing, which induced him to revert to artificial surfaces again. The plates ruled since 1869 are probably all of "mild" glass, thinned down to suit high powers. In 1869, he adopted a plan suggested by Dr. Woodward, namely, to rule on thin glass, and mount the ruled plate on another thin glass, the whole dropping into a countersunk opening in a brass plate 3 by 1 inch, on which the data of the rulings were engraved. Dr. Woodward suggested this plan in order to facilitate the employment of an achromatic condenser of large aperture and short focus.

The memorandum-book shows that in ruling a 30-band plate, Nobert commenced with the coarser lines, using a weight-pressure of 30 grammes on the diamond, which was gradually diminished until for the highest band he used only 3 grammes. A later entry seems to imply that he reversed the order of the ruling, commencing with the finest lines and lightest pressure.

I do not, as yet, know what means he adopted (if any) to secure his rulings from the effects of changes of temperature on the division-plate, &c., during the process of ruling. It is said that he removed from Greifswald to Barth, because in the former town he found the vibration detrimental; also that his finest work was done always during the night; on these matters I have no positive information at present.

In conclusion, I may express my conviction that the publication of the data obtained from the examination of the machine, and especially of the diamonds, will further the interests of micrometry. Several ruling machines exist in Europe and America capable of dividing space as minutely and accurately as Nobert's machine; but most, if not all, of them refuse to rule lines at all comparable to his when the closeness exceeds about 50,000 to the inch; and this is, I believe, mainly if not wholly, due to imperfection in the diamond, or in the method of regulating its pressure on the surface to be ruled.

I venture to predict that when the history of the mechanical inventions of our time comes to be written, a large measure of credit will be assigned to the mechanical genius of Herr Nobert, as embodied in this ruling machine.

DISCUSSION.

Mr. Warren de la Rue, D.C.L., F.R.S., wrote regretting his inability to be present, and added:—"I regret my inability the more as I was the first to possess, in England, Nobert's lines. In 1848, I had presented to me by a Swedish savant (whose name I forget), a plate containing two series of lines, the finest being distant from centre to centre $\frac{1}{50000}$ inch. Nobert was under the impression that no English object-glass could resolve these lines, and tested my power of seeing them, by asking me how many lines were in each band; my answer satisfying him, I induced him to rule some finer and finer, and I also ordered an object-glass of his make. This object-glass proved to be inferior to Ross's. On July 8th, 1849, I received a slide of sixteen series:—

Series.	Lines in each series.	No. of lines in an English inch.
1	7	11,261
2	8	13,056
3	9	15,426
4	10	18,163
5	11	20,475
6	13	23,461
7	15	28,153
8	17	32,175
9	19	37,537
10	21	40,950
11	23	45,045
12	24	47,327
13	26	50,050
14	27	52,870
15	29	56,306
16	57	112,613

The 15th series could be resolved with a Ross's $\frac{1}{4}$ in. object-glass of 77° aperture; the 16th could not be

resolved even by a $\frac{1}{1}$. Nobert's glass showed the 15th series with a fuzziness. In January, 1850, I received a slide of thirteen series:—

Series.	Lines in each series.	No. of lines in an English inch.
1	16	45,045
2	17	47,920
3	18	50,726
4	19	53,371
5	20	56,306
6	22	61,875
7	23	64,270
8	25	70,383
9	27	76,090
10	29	81,603
11	32	93,090
12	35	98,783
13	39	112,612

All the series up to 8th inclusive were resolved without difficulty; the 10th with great difficulty with a $\frac{1}{1}$ object-glass."

The CHAIRMAN said that all must have been interested in the very clear account which Mr. Mayall had given of Nobert's machine, although there were many points connected with it which could only be appreciated when the machine is seen close at hand, the parts being too minute to be seen at a distance. As had been said, Nobert claimed for his machine that the real test of the accuracy of the ruling was the optical test, viz., the question what kind of spectra would be produced from these lines. There was no doubt that the optical test was an exceedingly good one; the regularity of the spectra due to the interference and diffraction formed the real test of the accuracy of a ruling machine, and he would illustrate on the blackboard why this was the case. When light was either reflected or refracted by a series of rulings, and passed on to a screen, the rays which passed the edge of each line would spread away in the form of a wave in all directions, and in a certain position of the screen the rays from two adjacent openings would interfere with each other; if the difference of distance of any point on the screen from the edges of the two openings was exactly equal to half the wave length of a particular kind of light, at that point that particular kind of light would be absent. In this way, by the cutting out of light of a particular colour, *i.e.*, of a given wave-length, the difference of distance travelled might be determined. Thus, by taking the different parts of a grating, and measuring the positions of the interference bands produced in different parts of the grating, it could be seen at once whether the distances apart of the spectra were the same in all parts, and therefore the accuracy of the ruling could be tested. There could be no question that this was really the most severe test which could be applied. Many years ago, some beautiful gratings were ruled by Mr. Rutherford, of New York, with 15,000 lines to the inch. The successive spectra obtained from this grating, spread out to a very great length. In fact, a photograph taken with one of his gratings of the solar spectrum extended to some twelve feet in length, and the sodium band, nstead of being seen as a single band, appeared as two lines separated by 2¾ inches. By means of these gratings, therefore, some wonderful photographs might be produced, and the different dark lines in the solar spectrum were exceedingly well brought out. Professor Rowland had also produced some very remarkable gratings lately, ruled on a curved surface, instead of a plane, and he heard from those who had made use of these gratings that they were remarkably fine.

Mr. BRUDENELL CARTER said he had listened to the paper with the greatest possible interest. Many years ago, as a student, he remembered the new ideas which occurred to his mind on seeing for the first time Mr. Nobert's plates, and he had been greatly gratified by hearing Mr. Mayall's interesting description of the means by which they were produced. With regard to one statement in the paper, that it still remained to be explained under what optical or physiological laws stars which did not subtend an appreciable angle were perceived, he thought it was a matter which was capable of being clearly explained. The question of the visual angle under which an object was seen did not practically come into operation until the eye attempted the separation of two objects, the seeing of their distinctness from one another. The power of seeing a single object, such as a suspended telegraph wire, was entirely independent of its magnitude or of distance, or of the visual angle which resulted from those two quantities; it depended entirely on its luminosity relatively to its environment, and upon the power of the retina to distinguish a certain small increment or decremeut of light. The retina, which was the expansion of the optic nerve, was made up of a number of fine terminations termed cones and rods, of hexagonal shape, the whole surface presenting a mosaic appearance. In order to see separateness in two objects, the retinal image must be so large that the interval between the two objects occupied the whole of one retinal element or more. The individual retinal element clearly did not analyse the impression that it received. Consciousness of the nature of an object depended on the difference between the impression received by one retinal element and by those adjacent to it, but not on the impression received by one element alone. Now, if from any reason one retinal element received a greater or smaller amount of light than the element adjacent to it, and if the difference in that amount of light were sufficient to excite retinal consciousness, the acuteness of which probably differed in different people, the affected cone perceived there was some object there, without any reference at all to its magnitude. If, for instance, it required an angle of one minute to extend over more than one retinal element, two lines seen

under less than that angle would not be distinguished; but if the retinal element could appreciate a difference of $\frac{1}{60}$ in luminosity, over that impinging on its neighbours, then a line which only occupied only $\frac{1}{60}$ of its surface would be visible as a dark object. If there were two telegraph wires together, both falling within the same element, they would be totally indistinguishable, but would appear as one line; in order to see them apart, one must fall across one element or series of elements, and another on another. However numerous the lines, until their images were separated by an interval covering an entire cone, they could not be seen apart; but, however fine they were, until their fineness produced too small a variation of the total quantity of light, they would be visible as a continuous object. The reason why a fixed star was visible when Jupiter's satellites were not, was because the fixed star, although its image did not occupy the whole retinal cone, produced light enough to be distinguished, whereas Jupiter's satellites did not produce sufficient illumination for the difference to be distinguished.

The CHAIRMAN then proposed a vote of thanks to Mr. Mayall for his paper, which was carried unanimously.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

OPENING CEREMONY.

The Exhibition was opened on Monday, the 4th inst., and the arrangements were carried out in accordance with the programme given in the last number of the *Journal.*

The building was opened at a quarter-past ten, and before 12 o'clock it was filled in every part by a crowd of visitors.

On the arrival of their Royal Highnesses the Prince and Princess of Wales, a procession was formed from the Council-room where the Royal party were assembled. The Executive Council and the Foreign Commissioners led the way, and their Royal Highnesses followed in the following order:—The Prince and Princess of Wales, the Duke of Edinburgh and Princess Christian, the Duke of Cambridge and the Duchess of Edinburgh, Prince Christian and Princess Louise of Wales, the Princesses Victoria and Maude of Wales, and the suite. After passing through the Eastern Gallery the Royal party arrived at the Conservatory, and having taken their places on the daïs, Sir Frederick Bramwell, F.R.S., Chairman of the Executive Council, advanced and delivered the following address:—

May it please your Royal Highness,—As chairman of the Executive Council which your Royal Highness appointed to organise and carry out this Exhibition, I have the honour, on behalf of that Council, to welcome your Royal Highness within its walls, and to express the hope that you will permit us to briefly report upon our labours up to the present time. Acting upon your Royal Highness's instructions that the Exhibition should illustrate the progress of Inventions since the year 1862, and that of Musical Instruments and Appliances since the commencement of the present century, we first directed our attention to the preparation of a classification which should adequately embrace these subjects. In issuing this classification to intending exhibitors, we found it necessary, with a view of economising the limited space we had at our disposal, to lay down rules by which prominence should be more especially afforded to those inventions which the public had not had the opportunity of inspecting at recent exhibitions. For the purpose of examining the applications to exhibit, we deemed it necessary to institute a Committee of Advice. This Committee was accordingly formed, and includes the names of persons of the highest eminence, and of very varied attainments. The labours of the different committees were rendered extremely onerous by the vast number of applications received—a number far greater than we had space to accommodate. Our hearty thanks are due for the ready and valuable assistance which the members of the Committee of Advice afforded; but notwithstanding our best efforts, much was, for lack of space, excluded—a circumstance which, inevitable as it was, is a source of deep regret to the Executive Council.

As has been the custom at former International Exhibitions, letters were addressed, through her Majesty's Foreign-office, to foreign Governments, inviting them to appoint Commissions and to send contributions. It was probably owing to the unavoidably brief period granted for preparation that a more general response has not been received from abroad. Your Royal Highness will, however, be pleased to learn that influential Commissions have been nominated by Austria-Hungary, France, China, Greece, Italy, Japan, Russia, Siam, and Switzerland, from which countries interesting and valuable exhibits have been received or are promised. Through the efforts of Mr. Pierrepont Edwards, her Majesty's Consul at New York, a wide publicity has been given to this Exhibition in the United States, which has resulted in our having the pleasure of welcoming many exhibitors from that country. We regret that the Government of the United States has not felt itself in a position to appoint a Commission to represent so large and important a body.

The financial means for carrying out this Exhibition received our early attention, and efforts were successfully made to create a Guarantee Fund. The letters that were written on this subject met with so hearty a response that, instead of the £50,000 which was contemplated as the amount

that might be raised, more than £87,000 is now guaranteed; and this total is being augmented week by week. Your Royal Highness will, we are sure, appreciate the public spirit of the contributors to the fund; and we desire to take this opportunity of publicly expressing to them our sincere thanks for the encouragement and support which we have received from the manifestation of the interest which is felt in the Exhibition, as evidenced by the manner in which this Guarantee Fund has been described.

We are glad to be in a position to report that we have been able to make arrangements with the Council of the Royal Albert Hall, by which that building forms an integral portion of the Exhibition, with the National Fish Culture Association for the maintenance of the Aquarium, and with the Council of the Royal Horticultural Society for the holding of the usual periodical flower and fruit shows. The Old London Street, which was so popular a feature in last year's Exhibition, has been maintained. Your Royal Highness will have noticed that consderabie additions have been made to the Exhibition buildings. Many small annexes have been swept away, and in their places spacious galleries have been erected. Not only has greater exhibiting space been thus obtained, but the gardens, which are so great a source of attraction to visitors, have actually been enlarged. Notwithstanding the fact that the gallery used last year for machinery has been greatly extended to meet the requirements of exhibitors, it proved to be inadequate for the many important inventions for which motive power was desired; indeed, it has been found necessary to furnish such power in no less than three other galleries.

The employment of electricity for the purposes of lighting is undoubtedly one of the most striking instances of the application of science to the purposes of daily life; we have, therefore, not hesitated to give this subject special prominence. The method we have adopted will, it is believed, render any sudden failure of the lights impossible, and will favourably display the most recent and improved apparatus, and the advances that up to this date have been made in electric lighting. Our thanks are due to the many companies and firms who have aided us to attain this end. After most careful experiments we have ventured to employ, for the garden illumination, the incandescent electric lamp, and we have done so in a manner and on a scale which, we believe, has never before been attempted.

As a division of the Exhibition is devoted to music, we have set apart an important portion of the buildings to the illustration of instruments and appliances appertaining to that art; and we have invited the formation of a historical loan collection of musical instruments, which we believe is of a deeply interesting character. With a view of stimulating the love of music in this country, we are organising a series of choral and brass-band competitions, the prospect of which is already exciting much interest. These competitions will be held in the Royal Albert Hall during the autumn. With the assistance of the exhibitors, the Jury Commission nominated by your Royal Highness have appointed jurors, who will commence their labours within a few days.

The co-operation of the railway companies has enabled us greatly to increase the facilities of access for visitors to the Exhibition. The most important of these facilities is undoubtedly the subway from the South Kensington Station into the Exhibition; and, in that its construction under Mr. Wolfe Barry, as engineer, and Messrs. Lucas and Aird, as contractors, occupied but four months, it is itself a demonstration of the ease with which modern engineering, aided by mechanical inventions, accomplishes tasks which would formerly have been considered impossible. We are aware that your Royal Highness has taken a deep interest in the construction of this subway, not only out of regard to the comfort of the visitors to the Exhibition, but also on account of your earnest desire to remove the annoyance which large crowds thronging the Cromwell and Exhibition-roads must last year have caused to the inhabitants. We, the Executive Council, are most anxious to carry out your Royal Highness's wishes in this respect, and we believe that the subway will, in itself, go far towards the suppression of all annoyance to those who inhabit the neighbourhood. We have, however, conferred with the police authorities, and have ascertained that by means of improved regulations the traffic still remaining above ground may be conducted so as to give no cause for complaint.

In requesting your Royal Highness to declare this Exhibition open, we desire that it may, on the one hand, be the means of bringing valuable and meritorious inventions prominently before the general public, to the benefit and credit of the exhibitors, and that it may, on the other hand, be the means by which the public may, within the area of one Exhibition, be enabled to appreciate the marvellous progress which during the past quarter of a century every industry has achieved.

The Prince of Wales, in reply, said—It is with much pleasure that I have listened to the report of the Executive Council, and I fully appreciate the labours which you have bestowed upon this great underataking. At the closing of the International Fisheries Exhibition, I took the opportunity of expressing a hope that an International Inventions Exhibition might be held in these buildings during the present year; and I am sincerely gratified to find that this hope has been realised. The scope of this Exhibition is, indeed, vast, and I can readily comprehend the difficulties which must have beset you and the Committee of Advice in your endeavours to secure adequate representation for each branch of industry. I have observed with much pleasure that the classification originally adopted has been made the practical basis of allotment of space in the

Exhibition, and that the exhibits in each group have, as far as possible, been placed together. I am convinced that by following this plan you have materially increased the educational value of the Exhibition.

I readily echo the sentiments of gratitude which you have expressed for the invaluable aid rendered by the guarantors; and I join with you in welcoming the representatives of those foreign countries who are present here to-day. The interest which I take in the advancement of musical education leads me to hope—and I trust not without foundation—that the devotion of a special section to music will have the effect of encouraging the love of that art in this country, and I look forward to beneficial results from the competitions to which you have alluded.

I am sincerely pleased at the completion of an undertaking which has from its commencement had my cordial sympathy. I refer to the subway which I had the pleasure of declaring open on Saturday last, and I feel sure that this new access to the Exhibition will prove not only a great boon to visitors, but also in the manner in which you have indicated, a relief to the inhabitants of this district. In congratulating you upon the results of your labours up to the present time, I trust that your efforts will be rewarded by a success as great as that which attended the two previous Exhibitions. I now declare this Exhibition opened.

The Royal party then returned by the way of the western galleries, and left the building by the main entrance. About 25,000 persons visited the Exhibition during the day, and large numbers availed themselves of the subway to the South Kensington Station. which had been formally opened, on the previous Saturday, by H.R.H. the Prince of Wales.

PUBLIC GARDENS IN JAMAICA.

The annual report of the Public Gardens and Plantations in Jamaica, for the year ended 30th September, 1884, has recently been published. It is, indeed, something more than a record of what has been done even in introducing and propagating valuable economic plants, for many notes are given of the uses to which the plants are put in their native countries, thus making the paragraphs on the individual plants, to a certain extent, complete in themselves. Each of the gardens and plantations are reported under their individual heads. The Castleton Garden, for instance, which is the botanic garden of the colony, and is situated at an elevation of 580 feet above the sea, contains about ten acres, for the most part planted with tropical trees and palms. Of the Liberian coffee plants, it is said that all the trees in the plantation are vigorous and healthy, and at the time the report was written were bearing heavy crops of berries. Most of the trees had grown so bushy that it was found to be necessary for their well-being, and also to ensure a good crop of berries, to have them pruned. Of the olive (*Olea Europœa*) 200 plants were introduced to Jamaica during the year, fifty of which were planted in the Castleton Gardens, and are all reported as doing well. Mr. Morris says, "he believes that the olive will grow well in a strong, clayey, richly manured soil, but will not prove nearly so prolific as in a dry, calcareous, sandy, or rocky situation, and also that the temperature suitable for the orange will agree with the olive." A good many of the 160 plants of the Caraccas cocoa, which were put out in 1883, died during the severe drought, but they have been replaced by healthy young plants, and all the cacao plants in the plantation are in a healthy growing state.

The Ceara rubber tree (*Manihot Glaziovii*) appears to thrive well at Castleton, where seven large trees have been raised, the largest of which is 25 feet high, with a circumference of stem of 28 inches a foot from the ground. This kind of rubber-yielding plant is said to be more at home than any other rubber plants at Castleton. Mr. Morris says, being anxious to obtain a small specimen of Ceara rubber, the trees in the garden were tapped early in September, and although the trees were strong and healthy, the flow of milk was certainly small. The trees were, however, at the time of tapping, bearing heavy crops both of flowers and fruit. Of the Para rubber (*Hevea brasiliensis*) there is only one tree at Castleton, which is about 20 feet high, with a trunk 15 inches in circumference a foot from the ground. The tree bore a crop of fifty or more fruits last year. The *Cryptostegia grandiflora*, or rubber vine, is grown about Kingston as an ornamental climber. It abounds in milky juice, which is easily converted into rubber by the exposure to the sun for a short time. A plant of this was tapped at the same time as the trees of Ceara rubber, and a small specimen of rubber was obtained from it.

A good deal of space is given in Mr. Morris's report to the consideration of cinchona culture, as well as on the harvesting of bark and the manufacture of cinchona febrifuge. At no time perhaps has quinine been at such a low price as it is at present, but it is not at all improbable that the price will ere long advance again, so that if there is no real reason at the present time to produce cinchona febrifuge to sell at 2s. 6d. per ounce, while sulphate of quinine itself can be had at 4s., it may be necessary to have an efficient substitute to fall back upon at some not very distant date. Mr. Morris says, "Should the demand for cinchona febrifuge in the West Indies justify its manufacture being undertaken here, there would be a considerable saving effected at the plantations by the utilisation of prunings and thinnings, which often at present do not cover the expenses of curing and shipping, while at the same time an effectual and valuable febrifuge would be placed within the reach of the poorest."

The carob (*Ceratonia siliqua*) seems to promise

well in Jamaica. A tree planted in the Hope Nurseries, about four years ago, is said to be now 15 feet high, and other plants are now being raised from seeds brought from Madeira in order to establish a small plantation of this valuable food and fodder tree. The following description of the carob is given:—"This tree is extensively cultivated in countries bordering on the Mediterranean, and especially in such as suffer from periodical droughts, its long roots penetrating to a great depth in search of water. It is called Algaroba by the Spaniards, and Karoub by the Arabs, whence come our English name of carob or caroub, the pods being called carob pods or beans, or sugar pods. These pods contain a large quantity of agreeably flavoured mucilage and saccharine matter, and are commonly employed in the South of Europe for feeding horses, mules, pigs, &c., and occasionally, in times of scarcity, for human food." It is further stated that the gross export value of carob pods shipped from Cyprus during one year amounted to over £100,000.

The plantation of teak (*Tectona grandis*) which was established in 1845, consists of above 500 trees, covering eight to ten acres. The larger trees are nearly 40 feet in height, and measure 33 inches in circumference above the base. The soil, generally, is dry and gravelly, and the district, altogether, not of the most favourable description for this tree, which requires fairly rich soil, and more abundant rainfall. In spite of these unfavourable conditions, the trees are doing fairly well, and in time will yield a valuable supply of seeds for reforesting purposes, as also timber of superior quality.

Referring to an experimental cocoanut plantation, at Palisadoes, Mr. Morris says, in considering the conditions detrimental to the production of nuts, that they were to a great extent affected by attacks from the black rat. This animal, deprived of fresh water by the absence of rain, and the drying of pools, established itself permanently in the tops of the trees, and literally cleared them of all young nuts directly they began to form. Such nuts were found gnawed and eaten, lying thickly strewn over the plantation. Various attempts were made to dislodge the rats, and to destroy them. By these means, but chiefly by the timely return of the autumn rains, the injuries by rats have been greatly reduced.

Much attention has been given in Jamaica, of late, to the cultivation of fibre plants, and the preparation of the fibres, samples of many having been prepared and sent to London for trial and report, the full details upon which are given in the present report.

Under the head of "Bananas" the following facts are given:—Nearly the whole of the bananas at present are shipped to the northern ports of the United States, viz., New York, Philadelphia, and Baltimore. The trade with New Orleans is small and irregular. If, however, this important market could be fairly opened to Jamaica, there is no reason to doubt the trade might assume still larger proportions. The export of bananas, which is the chief fruit industry of Jamaica, amounted last year to 1,842,934 bunches, of the value of £191,972. Ten years ago the exports were only 85,083 bunches, of the value of £6,381. The development of this industry has brought into cultivation large tracts of land formerly lying useless, and it has also been the means of circulating nearly £200,000 per annum in ready money amongst all classes of the community. The particular kind of banana chiefly cultivated is the yellow kind, sometimes known as the Martinique, but now known in the United States as the Jamaica banana, to distinguish it from the large red banana, formerly exported in large quantities from Cuba. The Cuba banana has now been almost entirely replaced by the brighter and more attractive, as well as the more luscious fruit, from Jamaica.

The export of oranges from Jamaica is increasing very rapidly. Several well-kept plantations are springing up, which will probably yield superior fruit to any yet exported. The trees which yield the bulk of the oranges now exported from Jamaica are self-sown seedlings, growing in cattle pastures or in the neighbourhood of coffee or provision fields, and they receive little or no cultivation.

The Kola nut (*Cola acuminata*) is largely distributed in the island, and its cultivation is being extended in the hope that Kola nuts may utimately become an article of commerce. The tree is hardy and easily established, and there would be no difficulty in supplying large quantities of the nut every year.

Amongst other economic plants which have received attention during the year, and the results or prospects of which are recorded, may be mentioned cinnamon, camphor, nutmeg, olive, divi-divi (*Cæsalpinia coriaria*), cardamoms, tobacco, tea, mango, star anise, and many others.

BORAX IN THE UNITED STATES.

Mr. Sackville West, in his last report to the Foreign-office on the commerce and industries of the United States, says that nearly the whole of California, south of the Chon-chilla and Tresno region, and east of the coast range, is a silver and borax region, and Southern Nevada is much the same. The counties of Mono, Juyo, and San Bernardino, with part of San Diego, are the chief localities, though a remarkable line of borax deposits extends across Nevada, from west of Humboldt Sink to Desert Wells and Fish Lake, 140 miles south-east. The first discovery of borax in California was made in 1856, near Red Bluff, in the northern part of the State. The first deposits, however, successfully worked were those of the Borax and Hachinhama Lakes in Lake County, and 100 miles north of San Francisco. At present, the supply comes from the more easily worked and richer deposits in the sandy

deserts near Death Valley, and south-east of Pyramid Lake in Nevada. The first shipment of borax was made in 1864. The crystals of borax in the mud were removed by the use of coffer-dams, four feet square, and often nearly 1,000 lbs. were taken from one such space. In the deepest mud stratum the small crystals disappeared, and immense ones, often seven inches thick, were discovered, which required only solution and recrystallisation to render them fit for market. About the year 1868, operations ceased at Borax Lake, but continued at Hachinhama till 1873, producing annually 250,000 lbs. In 1866, the borax still remaining was estimated at 54,000,000 lbs. In San Bernardino deposits of tincal and borated sands have attracted considerable attention. The product is of the finest quality, and its manufacture has been highly profitable. The marsh is twelve miles long and eight miles wide. Borax minerals are found throughout this region, in a great variety of forms, as native borax, or tincal, as boracic acid, as ulexite, or borate of lime, as pricute, pandermite, and colemnite. The crude boraxes of the Pacific coast are usually of high quality, but the great difficulty is to economise labour and cost of transportation, and the effort is being made to produce the highly concentrated "boracic acid glass," one pound of which is equal to three pounds of common borax. The basin of Nevada in which the alkaline lakes or marshes of Mono, Owens, Walker, Carson, and Humboldt are situated is covered in many parts with dry efflorescent salts, washed in the course of ages from the soda feldspar of the volcanic rocks and ridges of yellow lava, which cover the country for miles. The waters of the lakes are heavy; they appear like thin oil, smell like soap, possess great detersive qualities, are caustic as potash, and easily saponify. The total yield of boracic acid in 1884, on the Pacific coast, was 2,800,000 lbs., and the total product of the West for the last twenty years has been 41,809,785 lbs. The demand for borax, says Mr. Sackville West, is increasing both in the United States and in the United Kingdom, whose annual consumption exceeds 25,000,000 lbs. supplied chiefly from the Italian marshes. The supply from the Pacific coast appears inexhaustible, but the difficulty of working it in the desert regions is very great.

Correspondence.

VENTILATION OF SEWERS.

It is always difficult, in a limited discussion, to explain every point so as to avoid giving rise to misapprehension. I am quite in accord with Mr. Buchan on some of his points. I quite agree with him as to the prudence of the course which he advocates in certain given instances. It is a way to prevent the evil which may arise from defective works and bad engineering. It will prevent evil to a given house, when the house-owner is helpless, as against the crass immovability of a satisfied municipality, when the authority is content to allow sewers of deposit (elongated cesspools) to exist in populous centres, and even in ordinary urban communities. But, nevertheless, it is not in the abstract a right proceeding; it is not strictly sanitary work; it is not natural. If a sewer flushes clean, as it ought to do; if it does not become the habitat of sewage confervoid growths upon its invert; that is, if it is regularly scoured above, as well as below the line at which the sewage ordinarily runs; if there is nothing to intercept the passage of sewage from its origin to its departure at the outlet: then there will be no sewer gas; there will be no stink; there will be no danger to anybody.

The openings on the inverts of the arch of the street sewer will be inlets for fresh air, and the ventilators produced by the extension of the soil pipe of every water-closet above the level of the house top will be outlets for the air which has passed through the sewer. Thus a constant circulation will be promoted at all times by the ordinary laws which belong to gases, and which by their very nature prohibit stagnation in fluids of all kinds. Occasionally there may be down draughts, but they will be of no more moment than the down draughts through an ordinary chimney—indeed, they will be as infrequent as a down draught into a furnace when the fire is low. Fresh sewage is not dangerous to anybody, but if it is kept within the curtilage of the dwelling-house by means of interceptors, or if it be allowed to stagnate in a badly-constructed sewer until fermentative changes have arisen within its substance, it then produces the chance of evil: but in the present day no authority ought to be allowed to keep sewage within its borders until such a change has taken place. It should be "moved on" out of range as rapidly as possible. The dangers which Mr. Buchan proposes to obviate are really increased by his interceptors. The house is the unit of sanitary work, and it is wrong for selfishness to assert itself so as to determine that no man shall assist the local authorities in its duty to provide for sewer ventilation.

I utterly object to the principle which is being tried to be established by various supposed authorities, viz., that the duties of the individual are antagonistic to the duties of the local authority in the matter of sewers. If each unit does his part, the duty of the local authority as to ventilation is simple. The latter has to convey away the sewage, and provide inlets for fresh air. The outlets must be at the highest points, and if they are so placed, there will not be a particle of danger from the production of sewer gas. An authority has an important duty to perform, viz., to prevent the production of sewer air, as a major part of its work. The provision for its escape, if it does accidentally form, will be best met by details in the construction of the house-drain.

Concentration should not take place, and without concentration sewer gas is perfectly harmless. There will be no diffusion of enthetic germs, for they cannot live in fresh air long enough to spread infective disease, and if, perchance, a few should be discharged in the higher regions above the heads of a great or small community, they die in a very few seconds.

The germs which reproduce enthetic disease cannot live in fresh air, any more than a fish can live in unaërated water. If discharged, they should be diffused above the heads of the people, and not at the street level. These are my reasons for advocating the extension of every soil pipe, so that each water-closet has a ventilator in action, and by this means properly constructed sewers will admit fresh air at the street level; and under common conditions, foul air, if produced, will escape, where it will fail to set up even the smallest possible danger. I advocated this principle twenty years ago, and experience, since my first paper upon this subject, has amply proved that I am right.

ALFRED CARPENTER, M.D.

Croydon, April, 1885.

INSTITUTE FOR LIVING LANGUAGES.

I have several times made appeals for greater facilities for learning living languages for commercial purposes, but with small results, although I received some support from the Society of Arts. It is now becoming a recognised fact that, in many branches of trade abroad, we are beaten by Germans and others, who have no greater aptitude for learning foreign languages, but who have better opportunities. Among Englishmen we have some of the best linguists in the world, as our Indian service can show; but in commercial matters we are inferior in this department.

There are numbers of young men who learn for heir amusement Hebrew, Anglo-Saxon, and Sanskrit —which are of no practical good—who might be made available for living languages. The existing means of instruction are in universities and colleges, where the students have as objects of pursuit the special business of their examination, and do not apply themselves to others. Beyond French and German classes in the institutes, and what is done in the City of London College, the provision in the metropolis is scanty; and the teaching being purely scholastic, most of the pupils break down, never reaching the vernacular stage, which is often made the last, and seldom the first. In the time of Queen Elizabeth, young ladies were better linguists than most men are now. The self-student has great difficulties. Take Japanese, for instance; books are difficult to be got. Aston's "Grammar of Spoken Japanese," a small book, is valued by Mr. Quaritch at £1.

My appeal for a school like the Ecole des Langues Vivantes, at Paris, which would cost very little, has been fruitless, so now I propose a beginning on a very smail scale indeed, which I trust will meet with the support of the Society of Arts in the first instance, and thereby of the public afterwards.

What I ask the Society of Arts to do is to allow any respectable young men to attend their reading-room, and to study such grammars and dictionaries as the Society has, and those as some of us would give or lend. Teacheis and examiners would offer themselves soon, certificates would be given, and it is to be hoped a permanent institute would be formed under the auspices of the Society for the Encouragement of Arts, Manufactures, and Commerce.

During the Crimean war the few men I was able to recommend to the Government, who knew Russian and Turkish, received ready employment, promotion; and my belief is that, through the gross neglect of our opportunities, there are as few available now as there were then for such a purpose, or any other.

HYDE CLARKE.

32, St. George's-square, S.W.
2nd May, 1885.

Notes on Books.

THE STRUCTURE OF THE WOOL FIBRE: in its Relation to the Use of Wool for Technical Purposes. By F. H. Bowman, D.Sc. Manchester: Palmer and Howe. 1885. 8vo.

In 1880, Dr. Bowman delivered a course of lectures on the structure of the cotton fibre, and early in the present year he gave another course in continuation of this one, which was devoted to the consideration of wool fibre, and it is the last course which forms the groundwork of the present work. The subject is treated under the following divisions—(1) Nature of wool and the industrial classification of sheep; (2) The typical structure of a wool fibre; (3) The nature of mechanical and chemical structure of wool. The author, in illustration of the importance of his subject, points out that more than one-tenth of the population of this country is dependent upon the cotton, flax, wool, and silk manufactures which are carried on here, and these four substances enter into the composition of nine-tenths of the clothing of the whole world. The book is fully illustrated with coloured plates of typical sheep and reproductions of microscopical sketches of cotton, flax, and silk fibres, of sections of skin, hair, of fibres, of various wools, mohair, alpaca, &c.

Obituary.

WILLIAM HAWES.—The Society of Arts has lost, in Mr. Hawes, one of its oldest and most honoured members, who twice held the office of Chairman of Council, and once that of Deputy-Chairman. William

Hawes, son of Benjamin Hawes, was born on May 23, 1805. In 1834, he took an active part in bringing forward a Bill for the amendment and better administration of the Poor-laws. He devoted much time in endeavouring to amend the Bankruptcy Laws, and in 1847 received the thanks of a large committee, with a handsome present of plate, in acknowledgment to the services he had rendered. He was also an active member of a committee for the amendment of the Excise laws relating to soap, for which labours he received, in 1841, a handsome testimonial of plate. He held up to the time of his death the office of treasurer to the Royal Humane Society, a society founded by his grandfather, Dr. William Hawes. Mr. Hawes was elected a member of the Society of Arts in 1849, and was for many years a member of the Council, and intimately associated with the Society's affairs. He took an active interest in the formation of the International Exhibition of 1862, and read three papers on the contents of that Exhibition before the Society of Arts. H.R.H. the late Prince Consort presided at the reading of the first, on June 7, 1861, and H.R.H. the Duke of Cambridge at the third on June 5, 1863. He was Chairman of the Council on the occasion of H.R.H. the Prince of Wales being elected President of the Society for the first time. In 1868, he was mainly instrumental in raising funds to send a deputation of skilled artisans to visit the Paris Exhibition. In 1877, he was appointed to fill the place of General Cotton, Chairman of Council, who was unable to attend from severe illness, and at the opening meeting of November 23rd, he delivered the chairman's address. Mr. Hawes married in 1833 the daughter of Mr. Samuel Cartwright, by whom he had 14 children, 11 of whom survive him.

General Notes.

Albert Exhibition.—The new building erected on ground adjoining Battersea-park, by the Albert Exhibition Company (Limited), is now completed, and on Saturday afternoon, the 25th April, the general arrangements were inspected by a large number of visitors, invited by the Directors. The building consists of a nave 60 ft. high, 473 ft. long, by 84 ft. wide, and with a gallery all round. There is an apse at the centre of the nave 50 ft. by 84 ft. In the annexe, known as the "Connaught-hall," 60 ft. high and 157 ft. long by 118 ft. wide, with a double gallery all round, which is adapted for musical entertainments, a concert was given on Saturday; and this concert-hall will accommodate an audience of from 3,000 to 4,000 persons. The "Holmes organ," built by Messrs. Bryceson Brothers, from the designs of Mr. W. T. Best, for Mr. Nathaniel J. Holmes, of the Hall, Primrose-hill, has been erected in this music-hall. The glass and iron used for the building were removed from Dublin, where they had formed part of the Dublin Exhibition building, and the marble columns in the dining-hall were originally in Baron Grant's mansion at Kensington. An exhibition of pictures was shown in the picture-gallery. It is expected that the Palace will shortly be opened to the public.

The Export of Wool from Turkey.—According to the *Constantinople Journal of Commerce*, the Porte has appointed a Commission for investigating the causes of the diminution of 50 per cent., which has taken place within the last two years in the exports of wool from Turkey. The annual production is said to be about 38,000,000 lbs., of which about one half has remained in the country from want of buyers. This is said to include a large proportion of the fine wool known as *Kasseppe Baschi*. The consequent depreciation of the value of wool has exercised an unfavourable influence upon the position of landed proprietors, and the national finances have also suffered from the cause referred to.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at Eight o'clock:—

May 13.—"A Marine Laboratory as a Means of Improving Sea Fisheries." By Professor E. Ray Lankester, M.A., F.R.S. E. L. Beckwith, Prime Warden of the Fishmongers' Company, will preside.

May 20.—"The American Oil and Gas-fields." By Professor James Dewar, F.R.S.

Indian Section.

Friday evenings at Eight o'clock.

May 8.—"The Ancient and Modern Methods of Treating Epidemics of Small-pox in India." By Surgeon-Major Robert Pringle, M.D., late Sanitary Department H.M. Bengal Army. R. Brudenell Carter, F.R.C.S., will preside.

May 15.—"The Golden Road to South-Western China." By R. K. Douglas, Professor of Chinese at King's College, London. The Hon. Edward Stanhope, M.P., will preside.

Foreign and Colonial Section.

Tuesday evenings at Eight o'clock.

May 19.—"New Britain and the Adjacent Islands." By Wilfred Powell. Sir Francis Dillon Bell, K.C.M.G., will preside.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings at Eight o'clock.

MAY 14.—"The Utilisation of a Natural Chalybeate Water for the Purification of Sewage." By Dr. JOHN C. THRESH. Professor W. ODLING, F.R.S., will preside.

CANTOR LECTURES.

Monday Evenings at Eight o'clock.

The Seventh and concluding Course, "The Manufacture of Toilet Soaps." By C. R. ALDER WRIGHT, D.Sc., F.R.S., F.C.S.

LECTURE II. MAY 11.—Plant and Appliances used in Soap Manufacture—Soaps made from free Fatty and Resinous Acids—Soaps made without Separation of Glycerine—Manufacture of "Boiled" Soaps, not containing Glycerine—Curd, Fitted, and Mottled Soaps; Modern Sophistications—Combination Processes—Manufacture of Toilet Soaps—Cold Processes for Opaque and Transparent Soaps—Remelting and Incorporating of various Ingredients—Refining—Recent Improvements—Manufacture of Milled Soaps.

LECTURE III. MAY 18.—Manufacture of Spirit-made Transparent Soaps—Machinery and Appliances employed in the preparation of Bars and Tablets—Cutting and Shaping—Squirting, cold and hot—Stamping and Drying—Valuation of Toilet Soaps by Chemical Analysis—Constituents often admixed, objectionable and otherwise—Discussions of Analytical Methods for the Determination of "Free Alkali," and Recent Researches thereon—Hydrolysis of Soaps in contact with Water—Classification of Toilet Soaps in accordance with the results of Chemical Analysis—Analysis of various British and Continental Soaps, and Discussion of their General Characters—Qualities requisite in Soaps intended for Delicate Complexions and Tender Skins.

ADMISSION TO MEETINGS.

Members have the right of attending all the Society's meetings and lectures. Every member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the members, but admission can also be obtained on the personal introduction of a member.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 11...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. C. R. Alder Wright, "The Manufacture of Toilet Soaps." (Lecture II.)
Geographical, University of London, Burlington-gardens, S.W, 8½ p.m. Mr. H. E. O'Neill, "East Africa between the Zambezi and Rovuma Rivers."

TUESDAY, MAY 12...Royal Institution, Albemarle-street, W., 8 p.m. Professor Gamgee, "Digestion and Nutrition." (Lecture IX.)
Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.
Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr. A. M. Thompson's paper, "The Signalling of the London and North-Western Railway."
Photographic, 5a, Pall-mall East, S.W., 8 p.m.
Anthropological, 4, St. Martin's-place, W.C., 8 p.m.
Colonial Inst., Westminster Palace Hotel, Victoria-street, S.W., 8 p.m. Sir Walter H. Medhurst, "British North Borneo."

WEDNESDAY, MAY 13...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Professor E. Ray Lankester, "A Marine Laboratory as a Means of Improving Sea Fisheries."
Geological, Burlington-house, W., 8 p.m. 1. Prof. T. Rupert Jones, "The Ostracoda of the Purbeck Formation; with Notes on the Wealden Species." 2. Mr. T. Mellard Reade, "Evidence of the action of Land Ice at Great Crosby, Lancashire." 3. Mr. D. C. Davies, "The North-Wales and Shrewsbury Coal-fields."
Graphic, University College, W.C., 8 p.m.
Microscopical, King's College, 8 p.m., W.C. 1. Mr. E. Wethered, "Structure and Formation of Coal." 2. Mr. A. W. Waters, "Use of the Avicularian Appendage in the Classification of the Bryozoa."
Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.
Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

THURSDAY, MAY 14...SOCIETY OF ARTS, John-street, Adelphi, W C., 8 p.m. (Applied Chemistry and Physics Section.) Dr. J. C. Thresh, "The Utilisation of a Natural Chalybeate Water for the Purification of Sewage."
Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Mrs. Shiel, "Physiology and the Laws of Health." (Lecture XI.) "Sight."
Royal Institution, Albemarle-street, W., 3 p.m. Prof. Tyndall, "Natural Forces and Energies." (Lecture V.)
Telegraph-Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. Professor Andrew Jamieson, "Electrical Definitions, Nomenclature, and Notation."
Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, MAY 15...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Prof. R. K. Douglas, "The Golden Road to South-Western China."
United Service Institution, Whitehall-yard, 3 p.m. Colonel Sir Charles H. Nugent, "Recent Colonial Acquisitions by Foreign Powers, and their Commercial and Strategical Aspect."
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Prof. Burdon Sanderson, "Cholera."
Philological, University College, W.C., 8 p.m. President's Annual Address by the Rev. Prof. Skeat.

SATURDAY, MAY 16...Geologists' Association, University College, W.C. Excursion to Hertford and Ware, under the direction of Mr. J. Hopkinson.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. W. Odling, "Organic Septics and Antiseptics."

Journal of the Society of Arts.

No. 1,695. Vol. XXXIII.

FRIDAY, MAY 15, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by the kind permission of the Executive Council of the International Inventions Exhibition, in the Exhibition-buildings, South Kensington, on Friday, the 3rd of July next.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. In addition to this, cards will be sold to members of the Society, or to persons introduced by a member, at the following prices:—Until the 20th of June, 5s. each; from that date until the 30th of June, 7s. 6d.; on the 1st, 2nd, and 3rd of July, 10s. each.

Tickets will only be supplied to persons presenting members' vouchers, (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

Members can purchase additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter, a remittance must be enclosed.

Light refreshments (tea, coffee, ices, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase. It will greatly facilitate the arrangements if members requiring additional tickets will apply for them at as early a date as convenient. The members' invitations will be issued early in June. Visitors' tickets can be purchased from the present date.

Further particulars as to the arrangements will be announced in future numbers of the *Journal*.

CANTOR LECTURES.

Dr. C. R. Alder Wright, F.R.S, delivered the second lecture of his course on "The Manufacture of Toilet Soaps," on Monday evening, 11th inst., in which he described the plant and appliances used in soap manufacture, and illustrated by experiments the processes adopted in the making of various kinds of opaque and transparent soaps.

The lectures will be printed in the *Journal* during the autumn recess.

SOCIETY OF ARTS' PRIZES.

The Council of the Society of Arts are prepared to award the following Gold Medals in connection with the International Inventions Exhibition:—

John Stock Prize.

Under the John Stock Trust, one Gold Medal, for the best application of Photography to a Permanent Printing Process, Group XXVI., Class 140; Group XXIX., Class 159.

Howard Prizes.

Under the Howard Trust, five Gold Medals, for the best exhibits (coming within the terms of the Trust*) in the following Classes:—One for the best exhibit in Group IV., "Prime Movers," Class 26. Steam - engines and Boilers. One for the best exhibit in Group IV., Class 27. Gas and Air Engines. One for the best exhibit in Group IV., Class 28. Means of Utilising Natural Forces. One for the best exhibit in Group XI., Classes 59 to 62. One for the best exhibit in Group XIII., "Electricity," Class 72. Distribution and Utilisation of Power.

Fothergill Prize.

Under the Fothergill Trust, one Gold Medal for the most novel and best exhibit in Group XXVIII., "Philosophical Instruments and Apparatus," Classes 148 to 158.

Alfred Davis Prize.

Under the Alfred Davis Trust, three Gold Medals to be awarded in Division II. of the Exhibition (Music), Groups XXXII. to XXXIV., Classes 166 to 180.

The Council propose to ask the Juries in

* The Trust was left "for the purpose of presenting periodically a prize or medal to the author of a treatise on the properties of steam generally, or any of them particularly, as applied to motive-power, or it may be of air or permanent gases, or vapours, or other agents so applied, or to the inventor of some new and valuable process relating thereto."

each Class to recommend for their consideration either two or three exhibits which they might consider deserving a prize. It will not be necessary for any special application to be made in respect of these Prizes.

A full list of the contents of the classes referred to above was given in the *Journal* of January 9th.

Proceedings of the Society

HOWARD LECTURES.

ON THE CONVERSION OF HEAT INTO USEFUL WORK.

By William Anderson, M.Inst.C.E.

[The right of reproducing these lectures is reserved].

Lecture V.—Delivered January 29, 1885.

At the conclusion of the last lecture, I explained how the waste of heat in furnaces, in which the work has to be done at a high temperature, is prevented by the Siemens Regenerator.

I will illustrate this principle farther by a still more interesting case, connected with the blast furnace for smelting iron ore.

A modern blast furnace for smelting iron ores consists of a hollow tower, with thick walls, hooped with iron, having the inside shaped principally in the form of two truncated cones, the upper cone having its smallest diameter at the top, or throat, of the furnace, and the lower one having its least diameter at the bottom, where it joins a smaller cylindrical part, or hearth, provided for holding the liquid iron. The top, or throat, of the furnace is fitted with a large iron hopper by means of which the fuel and ore are introduced. In all the best furnaces this hopper is closed by an iron cone, having its apex turned upwards, and capable of being lowered sufficiently to allow any materials in the hopper to drop into the furnace. Some of the modern furnaces attain to immense proportions, viz., 90 feet high, and 29 feet diameter inside at the largest part, with a capacity of 33,400 cubic feet. Many furnaces are not more than 60 feet high, and are even lower in districts where the coke used is of a soft character, or where coal is employed.

By means of the hopper, the proper proportions of fuel, ironstone, and limestone are continually supplied, the furnace being always kept nearly full night and day. The blast of hot air is forced in by means of tuyeres introduced through the sides of the upper part of the hearth. The pressure varies greatly, being least when charcoal is used as the fuel, and greatest with hard coke, or anthracite. The general pressure in this country is from 4 lbs. to 6 lbs. per square inch, but $10\frac{1}{4}$ lbs. is being used in America, in certain works, where as much as 1,833 tons of iron per week are produced from a single furnace, with the aid of "Cowper stoves." The action in the furnace is as follows:—The hot air, forced in at the hearth, enters immediately into intense combustion, with a corresponding quantity of carbon, thus producing carbonic acid gas and sufficient heat to melt the iron ore, which had been previously reduced in the upper part of the furnace, and also the limestone, which acts as a flux, so that both drop down into the hearth, the liquid iron sinking through the liquid slag formed of the limestone and refuse of the iron ore; the slag runs out continuously at a small hole at the side above the liquid iron, which is only tapped at intervals. The carbonic acid gas, in its upward course through the red-hot materials which are slowly making their way down, takes up another equivalent of carbon, thus becoming carbonic oxide, which, at a red heat, re-acts on the oxide of iron of the ore, and reduces it to a metallic sponge, the oxygen uniting with the carbon in the carbonic oxide, converting it again into carbonic acid, which, however, is again reduced by coming into contact with carbon from the fresh fuel.

The process goes on for a considerable portion of the height of the furnace, the temperature becoming lower and lower on account of the fresh cold materials continually added, until it gets too low for chemical re-action to proceed. The gases escaping ultimately are, therefore, chiefly carbonic oxide and the nitrogen of the air which was forced in at the hearth.

In olden times, these gases were allowed to escape freely at the top of the furnace, which was always open, and when using coal in the "Black Country," the gases burned with a bright flame, producing a conspicuous feature in the landscape.

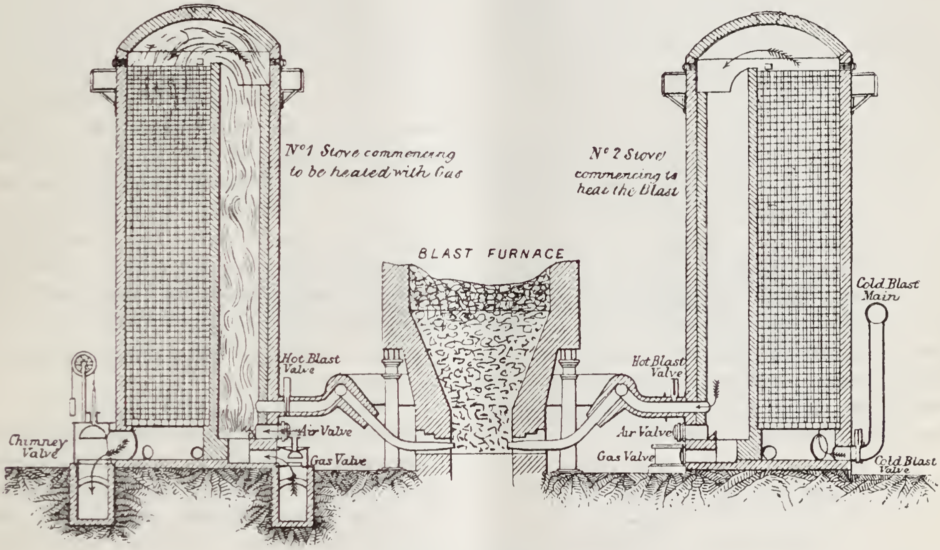
After the introduction of hot blast, however, the escaping gases were collected and carried down, by means of pipes, to heat the air entering the bottom of the furnace. A marked

economy of fuel, and an increase of yield, followed this grand improvement; but a limit to the temperature of the blast was soon reached from the want of some material to stand the intense heat of the air-heating stoves. Cast iron pipes in various forms, set in brick ovens, were used; the wear was very great, and the leakage from defective joints so serious, that high pressure blast could not be employed, nor the temperature of melting lead, about 600°, exceeded.

Here Mr. E. A. Cowper stepped in, and applied the regenerative principle to blast-heating stoves. These have now assumed grand proportions, 60 feet high and 25 feet diameter.

The stoves are worked in pairs, one stove of a pair being heated by the combustion of the gases brought down from the furnace top, and the other imparting the heat previously acquired to the blast. Each stove consists of an air-tight wrought-iron cylindrical casing, lined with firebricks. Towards one side a flame flue is carried up, while all the rest of the cylinder is filled with firebrick, formed in short lengths, and built up so as to make a honeycomb arrangement with walls about 2 inches thick. Each cell is continuous from top to bottom, but stops short of both, so that there is a chamber at the top, into which the flame-flue opens, and one at the bottom, connected with the chimney and the blast main.

FIG. 30.



COWPER STOVES.

The action is as follows:—The gases from the furnace are admitted by a suitable valve to the bottom of the flame-flue, and a supply of air, also controlled by a valve, is arranged to mix as intimately as possible with the gases. Complete and very intense combustion takes place in the flame-flue, and the highly heated products, having ascended to the top, pass down the honeycomb regenerator to the chamber in the bottom, and so through a suitable valve to the chimney. The heating of the stove goes on for several hours, until the full temperature has been attained to a sufficient depth in the regenerator; that is to say, to near the bottom. The gas, air, and chimney valves are then closed, the valve on the air main is opened, and the cold air admitted into the chamber under the regenerator; the air rises through the colder part first, then becomes fully heated, and passes through the remainder of the regenerator without taking up more heat, and after reaching the top, turns down the flame flue, and so passes through a valve to the tuyere, by which it is injected into the base of the furnace. As the stove works, the brickwork cools gradually from the bottom upwards, the upper layers changing very little in temperature, and when, after several hours, the cold zone has risen so high as to affect the temperature of the blast, the air is shut off, and the gas again turned on. In the

meantime, the fellow stove has been acting in the reverse direction, so that one stove is always heating the blast, and the other is being heated by the gas. The effect of this ingenious and simple invention is, that the blast can be heated to 1,600°, and the gases cooled to from 250° to 350°, without leakage, and with scarcely any wear and tear.

I said that the blast furnace is a particularly interesting case; the reason is, because the products of combustion are endowed with energy, partly in the form of heat, and partly in the potential state of carbonic oxide gas; so that if this gas were allowed to escape, even in a comparatively cool condition, a great waste of heat would take place.

The work due to the energy of combustion in the bottom of the furnace is expended partly in heating the cold materials charged into the furnace, partly in decomposing the hot fuel, partly in decomposing the limestone, and partly in detaching the oxygen from the ore. These operations reduce the temperature of the gases, in a well conducted furnace, as low as 374°, so that, at first sight, no great loss occurs; but if we analyse the gases, we find that associated with 12·1 per cent. of carbonic acid and 59 per cent. of nitrogen, are 26·1 per cent. of carbonic oxide and 2·51 per cent. of hydrogen. A reference to the table tells us that one pound of carbonic oxide burned to carbonic acid developes 4,326 units of heat; and one pound of hydrogen converted into vapour, 53,338 units, so that the combustion of the mixed gases will develop.

$$\begin{aligned} \text{CO } \cdot 261 \times 4{,}326 &= 1{,}129 \text{ units.} \\ \text{H } \cdot 0281 \times 53{,}338 &= 1{,}499 \text{ units.} \\ \text{Total} \ldots\ldots\ldots\ &\ 2{,}628 \text{ units.} \end{aligned}$$

These reactions require ·3738 lbs. of oxygen for their completion, corresponding to 1·714 lb. of air. Supposing the gases to burn at the top of the furnace with the theoretical quantity of air only, the temperature would rise $\dfrac{2{,}628}{2 \cdot 714 \times \cdot 238} = 4{,}068°$, so that by letting the gases escape, even cold, a very great loss would be experienced. It is possible, however, in consequence of the large proportion of neutral gases, amounting to 71 per cent., that a considerable excess of air is necessary to ensure complete combustion of the carbonic oxide and hydrogen, especially as the burners in the stoves do not mix the gases very perfectly. If we suppose that twice the quantity of air is necessary, then the temperature of flame will only rise $\dfrac{2{,}628}{4 \cdot 428 \times \cdot 238} = 2{,}494°$; and supposing the air at 50° and the gases at 400° the mixture of air and gas entering the stove will be at 129°; then the temperature of the flame will be 2,621°, equal to 3,131° absolute, a temperature at which cast steel will melt.

Bearing in mind Carnot's law, that the efficiency of a heat engine depends only upon the range of temperature, and is quite independent of what takes place during the working, provided always that the fall of temperature is caused by the work done, and Berthelot's law that intermediate reactions do not affect the final thermal results, we can compare the efficiency of various furnaces if we only know the extreme temperatures. Unfortunately, we have no means of measuring the temperature of the blast furnace where the heat is most intense; we must estimate it, therefore, by supposing that the rise of temperature is that due to the combustion of coke with the minimum amount of air, that is 4,588°; but this exceeds the limits we have set due to dissociation, which is 4000° absolute; let us then assume that as the maximum. Take, first, the open-topped furnace, in which the gases are not utilised, but burn at 2,000°, blast at 800°; the absolute temperature of the hottest part will be 4,000°, therefore the efficiency will be—

$$\frac{4{,}000 - 2{,}460}{4{,}000} = \cdot 38 \text{ or only 38 per cent.}$$

Next, take a blast furnace, using pipe stoves, from which the products of combustion go to the chimney at an ascertained temperature of 1,250°, or 1,710° absolute, and with the same temperature of blast as before, the efficient is

$$= \frac{4{,}000° - 1{,}710°}{4{,}000} = \cdot 57, \text{ or 57 per cent.,}$$

a gain of 19 per cent.; and, lastly, take the furnace with Cowper stoves, heating the blast to 1,600°, and allowing the product of combustion from the gases to escape to the chimney at 300°, we have the temperature of the furnace at 4,000° as before, but the smoke escapes from the stoves at only 760° absolute.

$$\text{The efficiency} = \frac{4{,}000° - 760°}{4{,}000°} = \cdot 81,$$

The Cowper stove, therefore, realises a saving of ·81 — ·38 = 43 per cent. over the open-topped furnace, and ·81 — ·57 = 24 per cent. over the pipe-stove furnace. Mr. Cowper states that, on the average of 100 furnaces, the

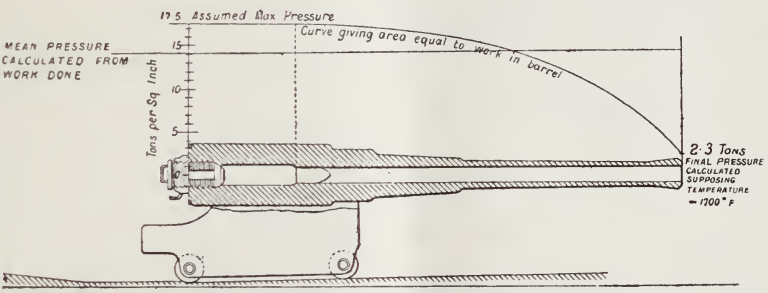
saving in practice is 20 per cent. in fuel, which agrees fairly well with the estimate we have made, based upon the truth of the general principles which I have explained.

The work done by the energy of combustion is so intricate, and requires consideration so purely chemical, that I will not attempt to bring them before you, I will merely mention that the effect of the Cowper stoves on the blast furnace is to make from 10 to 20 per cent. more iron, with a saving of coke ranging from 4 to 5 cwt. per ton of iron made, an advantage due to the improved chemical action, consequent upon the high temperature of the blast.

If it were possible to reduce the products of combustion in the stoves to the temperature of the atmosphere, say 50°, the duty would increase to 80 per cent, and beyond that it will be impossible to increase the economy of a furnace. Through the kindness of Mr. Cowper, I am enabled to show you a high temperature thermometer, such as is used by him in ascertaining the heat of the blast. It is, in principle, the same as the pyrometer described in my third lecture, but a ring of copper is used instead of a platinum ball, and the mercury thermometer in the water space is fitted with a sliding scale, the zero of which can be set to the end of the column of mercury, wherever it may be. The scale is graduated by experiment, so that the temperature attained by the ring can be read off at once. The pyrometer was first described by Mr. Wilson, of the Bridgewater Works, St. Helens, in 1852. The instrument before you has been manufactured by Messrs. Siemens and Co., hence it is commonly, though erroneously, known as the Siemens pyrometer.

I am also indebted to Mr. Cowper for this working model of one of his stoves. A large Bunsen burner has been heating it for several hours, and yet the products escaping at the

Fig. 31.



Curve showing probable Pressure in Bore.

top are so cool that they are carried off by this paper chimney. I now remove the stove from its stand, and set it on a pad of clay. I close the top by means of a zinc plate luted down with clay and secured by a weight. I then turn on a blast of cold air from the top downwards, the blast of air issues by this side opening near the bottom, and is so hot that it easily melts this strip of lead which I hold in the current, and sets fire to this twist of paper the moment I bring it within its influence.

The simplest machine in use for the conversion of heat into work is a gun. It is a single acting engine which completes its work in one stroke, and does not, like most engines, work in a continuous series of cycles. In the discharge of artillery many interesting considerations arise, and as I believe that the illustration of a particular case will fix itself better in your memories and be more intelligible, I will take the case of the new pattern 10-inch breech-loading rifled gun. This weapon weighs 27 tons, is 26 feet 8 inches long, and discharges a shot weighing 500 lbs., impelled by the energy latent in 300 lbs. of gunpowder, with a muzzle velocity of 2,100 feet per second, the shot, at the same time receiving a rotatory motion of 84 revolutions per second.

From the experiments of Sir Frederick Abel and Captain Noble, we know that the maximum temperature of the explosion of pebble powder is 4,420° Fahr. absolute. The temperature of the gases issuing from the muzzle of the gun has not been measured, but it certainly attains to a bright red heat, which is about 2,160° absolute. The powder, therefore, works between the temperatures of 4,420° and 2,160°; the duty which we may expect will consequently be, according to Carnot's law—

$$\text{Duty} = \frac{4{,}420 - 2{,}160}{4{,}420} = \cdot 5113$$

that is to say, we must not expect to realise more than 51 per cent. of the heat developed in the combustion of powder.

From the authority already quoted, we learn that the explosion of a pound of powder developes 1,300 units of heat. The specific heat is given as ·183 at constant volume, hence the total heat resident in exploded powder, at an atmospheric temperature of 50°, or 510° absolute, is—

$$\left\{ 510^{\circ} \times \cdot 183 \right\} + 1{,}300 = 1{,}393 \cdot 3 \text{ units,}$$

and of this we can only expect to realise—

$$1{,}393 \cdot 3 \times \cdot 5113 = 712 \cdot 41 \text{ units,}$$

corresponding to $\dfrac{712 \cdot 41^{u} \times 772^{J}}{2{,}240 \text{ lbs.}} = 245 \cdot 53$ foot tons of energy per pound of powder, so that the total charge of 300 lbs. should be capable of producing work amounting to 73,658 foot tons.

The work done by the discharge of the gun must be classed under two heads:—

I. Work external to the gun, the reaction of which causes recoil, and

II. Work self-contained in the gun which produces no visible effect upon it.

To the first class belong—

1. The energy imparted to the shot in its forward motion.

2. The energy absorbed in the expulsion of the powder gases.

3. The work done in displacing the atmosphere by the ejection of the shot and powder gases.

To the second class belong—

4. The energy expended in producing rotation in the shot.

5. The work done in overcoming the friction of the gas check.

6. The work done in stretching the material of the gun, in setting up vibratory motions, and in compressing the shot and breech-block.

7. The friction of the powder gases against the bore of the gun.

8. The energy absorbed in heating the gun.

I will deal with these items in detail.

1. The muzzle velocity of the shot can be determined with great accuracy by experiment, and, in the particular gun we are considering, has been found to be 2,100 feet per second; consequently the energy imparted to

$$\text{Shot} = \frac{500 \text{ lbs.} \times 2{,}100^2 \text{ ft.}}{64 \cdot 4 \times 2{,}240 \text{ lbs.}} = 15{,}285 \text{ foot-tons.}$$

2. The combustion of gunpowder results in about 57 per cent. of very finely divided solid matter and 43 per cent. of permanent gases. That the solid matter *is* in a very fine state of subdivision may be inferred from the slowness with which powder smoke falls to the ground. When large guns are fired at sea, and heavy clouds of smoke are formed, they sail over the water for many miles, and remain visible for a long time, though fired within a few feet of the sea level; hence the particles must be very minute.

The condition within the bore of the gun is not indeed the same, because the smoke formed is the result of chemical action after the gases have left the gun; but the particles of solid matter in the bore are certainly not larger than those which form the smoke, and though they constitute 57 per cent. of the cloud, they do not sensibly alter its gaseous properties; and, therefore, the mixtures of solids and gases, forming the products of combustion of powder, may be treated, as far as its physical properties are concerned, as all gaseous, but of a higher specific gravity than the pure gases evolved. At the moment of the shot leaving the muzzle, it has been ascertained by experiment, though not in a trustworthy manner, that the gas pressure is about 3,875 tons, or 8,680 lbs. per square inch; the volume of the bore of the gun is 16·72 cubic feet; hence the 300 lbs. weight of powder gas occupying that volume must weigh 17·94 lbs. per cubic foot; consequently, the pressure will be represented by a column of gas, of the above density,

$$= \frac{144 \text{ sq. in.} \times 8{,}680 \text{ lbs.}}{17 \cdot 94 \text{ lbs.}} = 65{,}013 \text{ feet high.}$$

When the muzzle of the gun is suddenly opened, the gases will begin to issue as from an orifice in the side of a vessel, with a velocity proportional to the height of the gaseous column $= 8 \cdot 05 \sqrt{65{,}012} = 2{,}125$ feet per second, or very little more than that of the shot, which seems to indicate that the 10-inch gun cannot, with advantage, be increased in length without increasing the charge of powder. Supposing the whole body of gas to issue with the above velocity, then the energy expended will be $\dfrac{300 \text{ lbs.} \times 2{,}125^2}{2{,}240 \text{ lbs.} \times 64 \cdot 4 \text{ feet}} = 9{,}388$ foot-tons. But the gases being elastic, their whole body will not move at the same speed, so that the above calculation may be erroneous to a considerable extent. The limits between which the energy absorbed in the expulsion of the powder gases will vary may, I think, be

determined by the following considerations. One pound of powder produces 4·485 cubic feet of gas at the freezing point, and under the pressure of one atmosphere. This volume would be increased to 4·651 cubic feet at a temperature of 50°, consequently 300 lbs. of powder would yield 1,395 cubic feet of gas at atmospheric pressure and temperature. We must suppose that this gas will obey the laws applicable to all permanent gases. its specific weight is nearly three times that of air, hence the work done in heating at constant pressure will be less, the value of γ consequently is only 1·143 if the specific heat at constant volume is taken as ·183. Suppose the gases violently compressed into the bore of the gun, measuring $16\frac{1}{2}$ cubic feet, the pressure would arise according to the ordinates of an adiabatic curve, and we should have, finally, $p = \frac{14 \cdot 7}{2{,}240}\left(\frac{1{,}395}{16 \cdot 72}\right)^{1 \cdot 143} = 1 \cdot 03$ tons pressure per square inch in the gun, and a temperature of t : $510^\circ \left(\frac{1{,}395}{16 \cdot 72}\right)^{\cdot 143} = 960^\circ$ absolute. The work done in compressing the gas would be—

$$w = \frac{1{,}395 \text{ c. ft.} \times 2{,}117 \text{ lbs.}}{\cdot 143 \times 2{,}240} \left\{ 1 - \left(\frac{1{,}395}{16 \cdot 72}\right)^{\cdot 143} \right\} =$$

8,131 foot-tons. Now, the compressed gas, if suffered to expand suddenly, would do the same work, and the reaction on the gun, according to Newton's third law, would be the same. This, I think, would mark the superior limit of work done in expelling the gases. If, on the other hand, the gases were compressed slowly into the gun without change of temperature, the pressure would rise along the ordinates of an isothermal curve, and would only reach ·55 tons per square inch pressure, and the work done would be 5,833 foot-tons. This would fix the lower limit. It is certain that the gases, at the moment when the shot leaves the muzzle, have a much higher temperature than 960° absolute. The work done in the bore of the gun, we shall see presently, amounts to about 28,931 foot-tons, corresponding to 83,900 units of heat, which must disappear, as heat, from the powder gases; the fall of temperature, consequently, will be $t = \frac{83{,}900 \text{ lbs.}}{300 \text{ lbs.} \times \cdot 183} = 1{,}528^\circ$, which, deducted from the temperature 4,420° due to energy of chemical action in the combustion of the powder, leaves 2,892° absolute as a possible temperature at the moment of the shot leaving the gun, if no allowance is made for a farther fall caused by loss of heat expended in warming the gun and shot, This temperature is only 732° higher than that which I have assumed.

The usual method adopted in artillery text-books of estimating the energy expended in expelling the powder-gases, when it is not overlooked altogether, is to consider that from one-half to the whole weight of powder is expelled at the same velocity as the shot, but this is mere assumption, without any rational foundation, and takes no account, either of the proportions of the gun or the pressure in the bore, the latter being a function of the nature of the powder and mode of ignition. Upon the whole, I am inclined to think that the method which I indicated to the Ordnance Committee last June is fairly correct, namely, that the energy expended in the expulsion of the powder-gases should be taken on the supposition that they are blown out of the gun at the velocity corresponding to their ascertained pressure, at the moment when the shot leaves the muzzle. The formula is :—

$$\text{Velocity of gases} = 4{,}544 \sqrt{\frac{\left(\text{Pressure in tons per square inch}\right) \times \left(\text{Volume of bore in cub. feet}\right)}{\text{Weight of powder in pounds.}}}$$

When the weight and velocity are known, the energy is, of course, easily calculated. The terminal pressure is difficult to arrive at. I do not believe that any gauges yet invented give trustworthy results, because the time during which the record has to be taken is so short. It may seem strange that the pressure curve in the bore of a gun cannot be determined by direct calculation, but the reason is, that the powder continues to burn and evolve gas during the greater part of the time that the shot is travelling along, and, as the rate of evolution is unknown, of course no formula can be constructed on purely theoretical considerations.

3. The displacement of the atmosphere. I shall, later on, allude to the rapidity with which the gases are expelled from the gun. I will merely state now, that the action is extremely rapid, and that the reaction to the effort of parting the air must be a pressure on the base of the bore.

We have assumed a temperature of 2160° for the gases at the moment of the shot leaving the muzzle. The pressure due to gases at 50°, suddenly compressed into the gun, we found to be 1·03 tons per square inch, and the temperature 960·1°. The pressure corresponding to 2,160° would be equal to :—

$$\frac{1{\cdot}03 \text{ tons} \times 2{,}160^{\circ}}{960{\cdot}1^{\circ}} = 2{\cdot}32 \text{ tons}$$

per square inch, or 5,194 lbs. In expanding suddenly, the temperature would fall to

$$t = 2{,}160^{\circ}\left(\frac{14{\cdot}7 \text{ lb.}}{5{,}194 \text{lb.}}\right)^{\cdot 125} = 1{,}037^{\circ}$$

and the volume would become

$$\frac{1{,}395 \text{ c. ft.} \times 1{,}037^{\circ}}{510^{\circ}} = 2{,}837{\cdot}4 \text{ c. ft.}$$

Deducting 5 cubic feet for the volume of the solid powder, we have 2,832·4 cubic feet of air displaced. The work of doing this will be—

$$W = \frac{2{,}832{\cdot}4 \text{ c. ft.} \times 2{,}117 \text{ lbs.}}{2{,}240 \text{ lb.}} = 2{,}677 \text{ foot-tons.}$$

4. The rifling of the gun causes the shot to spin on its longitudinal axis as it traverses the bore. The angle of the rifling at the muzzle is such that the shot makes one revolution in thirty calibres, that is, in 300 inches, or 25 feet; hence, dividing the muzzle velocity by 25, we get the revolution per second to be 84. Now the diameter of the circle of gyration of a cylinder 10 inches in diameter is 7·072 inches, and its circumference 1·851 feet; therefore, at 84 revolutions per second, the velocity at the circle of gyration will be 1·851 feet × 84 = 155·52 feet per second, and the energy

$$\frac{500 \text{ lbs.} \times 155{\cdot}52^2}{2{,}240 \text{ lbs.} \times 64{\cdot}4} = 83{\cdot}82 \text{ foot-tons.}$$

The reaction to this motion is twofold. Firstly, the resistance of friction of the rifling balanced by the pressure of the gases, and therefore a self-contained strain; and secondly, a tangential pressure, tending to rotate the shot, balanced by an effort to turn the gun in the opposite direction. Neither of these motions have any effect on the recoil.

5. The friction of the gas check is a matter of pure estimate, especially with the ring checks now in use. I assume a mean pressure of powder gases of 12 tons per square inch, and suppose a copper band of ½ inch effective depth pressed against the surface of the bore with that pressure. Taking the coefficient of friction at ·14 we have a surface of 15·7 square inches in contact under a pressure of 12 tons, and a space passed over of 22·5 feet, the work done will therefore be—

$$15{\cdot}7 \text{ sq. in.} \times 12t \times {\cdot}14 \times 22{\cdot}5' = 593{\cdot}5 \text{ foot-tons.}$$

The force assumed is equivalent to a pressure of ·35 tons per square inch on the base of the shot, or ·87 tons per lineal inch of circumference. I believe that actual experiment has shown that to force a shot slowly through the bore requires a pressure of half ton per square inch in the smaller guns, but necessarily this is a very variable and uncertain quantity.

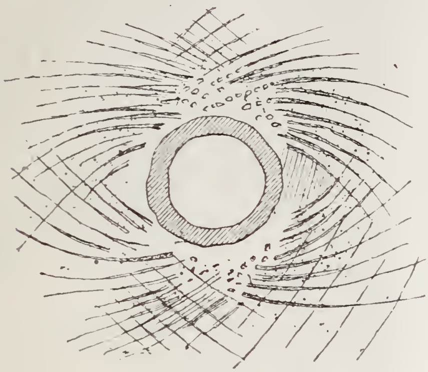
6. The energy expended in stretching the gun and compressing the shot and breech block is very difficult to estimate. The 10-inch gun is supposed to have a factor of safety of about four, so we may assume that the metal is impressed with a strain of six tons per square inch. The mean volume of the gun, that is the volume to the centre of the metal, is about 49·45 cubic feet, and I estimate that this will stretch to 49·696 cubic feet, absorbing ·246 c. ft. × ·144 sq. in. × $6t = 212{\cdot}5$ foot-tons. The strain, however, does not come on uniformly, but follows the shot along the bore, giving rise to a wave-like motion which must produce cross strains difficult to estimate, but very serious, especially where guns are built of rings suddenly changing very much in diameter. There are, besides, other sources of vibration. The powder burns unequally, and most probably the gases evolved are traversed by pulses which must be communicated to the metal which confines them. In the modern long light guns, the weight of the shot, as it travels along the bore, sensibly depresses the muzzle, and this movement is aggravated by the powder heating the upper half of the gun more quickly, and to a greater extent, than the lower. The moment the shot leaves the muzzle, the barrel springs back, and vibration which, I understand, is actually visible to the eye, is set up. Again, the powder gases, as they rush out, rub so hard against the sides of the bore that they actually, in places, erode the metal, and must produce longitudinal pulses similar to those you have seen induced by friction in the brass and glass tubes of the apparatus for demonstrating the existence of molecular motion producing sound.

The simultaneous occurrence of vibrations of different wave length and intensity in a gun, implies that there will be interference, that is to say, as in the case of waves of sound or undulations in water, waves may coincide and produce a more intense effect, or, on the other hand, they may neutralise each other wholly or in part. It is well-known that guns of different calibre and different metal have each their peculiar ring, which is audible through the main sound of the discharge, like overtones on a fundamental note in music.

Messrs. Chernoff and Beck-Gerhard, of St. Petersburgh, have noticed and described the manner in which sudden strains, such as those

caused by punching, shearing, or hammering, are propagated through steel plates. By operating on polished plates, they have been able to render the waves of strain not only visible to the eye, but sensible to the touch, because the metal is strained beyond its elastic limit both in tension and compression,

FIG. 32.



STRAINS DEVELOPED BY PUNCHING.

and consequently remains impressed with wave-like hollows and ridges. Mr. Chernoff suggests that similar abnormal lines of strain may arise in the metal of guns, and lead to the otherwise unaccountable failures, especially of inner tubes, which so often take place.

7. The friction of the powder gases against the sides of the boie it is impossible to calculate with even an approach to accuracy, because we cannot tell whether the laws and coefficients applicable to ordinary temperatures and pressures will apply under the circumstances. Yet supposing that they do, and that the hot powder gases will behave like air, we may take the mean pressure we have already assumed of 12 tons per square inch, and an average speed of 1,000 feet per second through a bore 26 feet long, and applying the ordinary formula for the friction of air in pipes, we obtain a resistance of 690 foot tons. This may seem an altogether exaggerated estimate, but it must be remembered that the friction of gases increases as their pressure and as the square of their velocity, and that we are dealing with very high figures in both respects. It is also well to note that the friction of the gases close to the powder chamber, where the temperature and pressure are greatest, and where they expand after the temporary contraction caused by passing the shoulder of the chamber, and therefore strike with increased energy against the bore, is sufficient to score and rasp away the metal, and become by that means the chief agent in the deterioration of guns.

Dr. BALANCE SHEET OF 10-INCH GUN. *Cr.*

	Foot tons.			Foot tons.	Foot tons.	Per cent.	Per cent.
			I.—EXTERNAL WORK.				
Available energy of 300lbs. of powder working between 4,420° and 2,160° absolute		1	Energy of shot	15,285			
		2	,, of expelled gases	9,388			
		3	,, in displacing air..........	2,677			
	73,658				27,350	37	94
			II.—INTERNAL WORK.				
		4	Energy of rotation	84			
		5	,, in friction of gas checks ..	594			
		6	,, in stretching gun	213			
		7	,, in friction of gases	690			
					1,581	2	6
			,, in heat imparted to gun and shot = 17·9° ..	44,727			
					44,727	61	
	73,658				73,658	100	100

Collecting all the items we have been discussing into the form of a balance sheet, we find that the discharge of the 10-inch gun performs 27,350 foot tons of external work, and 1,581 foot tons of internal work. The available energy of the powder is 73,658 foot tons; hence there remains a balance unaccounted for on the credit side of 44,727 foot tons, which must

have been chiefly expended in communicating to the metal of the gun the molecular motion which becomes apparent in the form of heat. This energy represents

$$\frac{44{,}727 \text{ foot-tons} \times 2{,}440 \text{ lbs.}}{772_J} = 129{,}780 \text{ units.}$$

The gun and shot weigh 60,880 lbs., and being of steel, have a specific heat of ·119, and therefore the rise of temperature of the gun from each discharge may be expected to be not more than

$$\frac{129{,}780\ u}{60{,}980 \text{ lbs.} \times \cdot 119} = 17{\cdot}9^{\circ}$$

This temperature will be very unequally distributed, and very quickly dissipated by radiation and conduction from the large surface of the gun.

Referring again to the balance sheet, we have estimated that the external work done in the discharge amounts of 27,350 foot-tons, composed of three items, one of which, the energy necessary to expel the powder gases, is uncertain. The work being external, there must be the same amount of work in the recoil, because, according to the third law of motion, to every action there must be an equal and opposite reaction, and, therefore, the quantity of motion must be the same. The pressure producing recoil lasts only so long as the shot and powder gases are being expelled from the gun, and consequently the time during which the maximum velocity of recoil is reached must be the same as the time consumed in the discharge, for acceleration ceases the moment the acclerating force ceases to act. Recoil, however, does not become visible simultaneously with the discharge, because a certain interval of time is necessary to transmit the pressure against the base of the bore of the gun to its carriage, so as to cause the latter to move. The gun stretches longitudinally, the trunnions compress the metal of their bearings, the material of the carriage stretches, and hence an appreciable delay occurs before visible motion begins, but is made up for by the persistence of the motion for an equal time after the discharge, because the reaction to the stretching of the system keeps up the acceleration. I have witnessed an interesting illustration of this fact in the case of the short 6·6 inch muzzle loading gun, mounted on a Moncrieff hydro-pneumatic carriage. The muzzle of the gun, when in the firing position, happening to be close to the concrete parapet, the powder gases, the instant the shot left the muzzle, flashed out as a disc of fire, and marked the parapet as sharply as if it had been done with black paint, and the margin of the discoloration next the gun was exactly in line with the muzzle when in firing position, proving thereby that no sensible motion of the whole gun has commenced till after the shot had left the bore.

In addition, although the gun recoiled instantly below the parapet, starting into motion at the rate of 22 feet per second, so that the muzzle of the gun must have been below the parapet in about $\frac{1}{20}$ of a second, yet not the slightest discoloration of the concrete was observable on the inside of the parapet even after many rounds. This is the evidence which I have alluded to in support of my statement that the gases are wholly expelled from the gun in a very short space of time, and must exert a correspondingly serious effect on the gun.

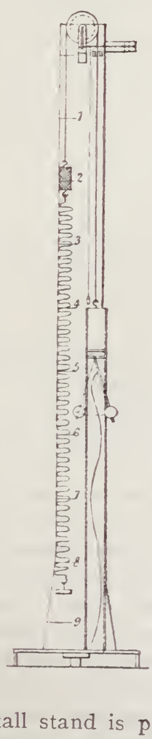
But not only must the accelerated motion of recoil take place in the same time as that occupied by the discharge, but because, according to Newton, velocity is proportional to the impressed force, the rate of acceleration of the shot and gases as they move along the bore at each instant, must have its counterpart in the motion of recoil; hence the curve of velocities of recoil, could we construct one, would correspond to that for the velocities in the bore, but on a reduced scale. Because of the quantity of motion in the discharge and recoil being equal, and of the weight of the gun and its carriage being much greater than that of the shot and gases, the motion of the former will be so much slower than that of the latter, and therefore more easily registered. But how are we to obtain a faithful picture of the motion of recoil? The answer is, by means of a beautiful instrument invented by Colonel Sébert, of the French artillery.

This apparatus consists of a solid pedestal secured to the ground beside the gun carriage. A tuning fork is fixed to the pedestal, and kept in vibration by means of a galvanic current. To one prong of the fork is attached a stile or tracer, so arranged that it will scratch a wavy line upon a strip of blackened metal, one end of which is attached to the carriage, which, in recoiling, draws the strip along under the tracer. The tuning fork is adjusted to make 500 complete vibrations per second, this corresponds very nearly the middle C of the musical scale. If a centre line is drawn through the undulations, each complete beat will cut the line twice, so that each intersection will measure

the $\frac{1}{1000}$ part of a second, and the pitch of each half wave will be the distance passed through in that minute fraction of time. The diagram traced will, therefore, give all the information which we require, namely the total time of the accelerated motion of recoil, which will be up to the point where the waves attain their maximum pitch, the maximum velocity of recoil, and the rate at which the recoil is accelerated throughout, so that, knowing the weight of the gun and its carriage, we can determine the energy at any point, and, as I have already stated, this must be the counterpart of what takes place in the bore. A special instrument, provided with micrometers and a magnifying glass, is used for measuring the pitch, the amplitude of the vibrations, and the angle at which the wave line cuts the centre line.

I have here an apparatus which will illustrate Sébert's instrument. Over the pulley

FIG. 33.



secured to this tall stand is passed a cord, to one end of which is attached a lath covered with a strip of paper, and to the other end is hung a weight, so adjusted as to give a moderate speed to the lath. As I showed you in my first lecture, the lath will move with uniformly accelerated velocity. In front of the lath hangs a pendulum, which makes a double swing in one second. Attached to its rod, near the point of suspension, is a pencil, which presses on the paper. I first allow the lath to rise, while the pendulum is stationary; the pencil traces a straight centre line. I draw down the lath, and set the pendulum swinging; the pencil traces a short arc. I now release the lath, which moves upward, and the pencil traces a wavy line, which intersects the centre line previously traced. Each intersection defines the space passed through in half a second, and when we measure the total lengths cut off in 1, 2, 3, 4 half-seconds, we find them to increase in the ratio of 1, 4, 9, and 16, which we know to be the rate of increment proper to a continuously acting force, such as gravity. On the diagram I have drawn this wave-line. Hence, suppose the Sébert machine were to trace one like it, we should know at once that the pressure of gases in the bore of the gun must also have been uniform.

I now balance the weight of the lath exactly, and attach a spiral spring to the cord by which it was raised. In pulling down the lath I bring the spring into tension. I start the pendulum, and let go the lath; a curve is traced which represents velocities produced by a uniformly decreasing, accelerating force, such as a spring. I have represented this also on a diagram, and were the Sébert apparatus to trace such a curve, we should know that the pressure in the bore was uniformly decreasing.

In all cases, supposing the carriage to recoil down an incline which would exactly compensate for friction, the curve, whatever its nature might have been during acceleration, would terminate in waves of equal pitch, corresponding to the maximum velocity attained because, according to the first law of motion, the carriage would continue to move at a uniform velocity so soon as the impelling force ceased to act. The proper way, therefore to measure the recoil, is to mount the gun on a well made carriage, placed on an evenly laid line, which would, for the first two or three feet, fall in the direction of recoil at an incline corresponding to the friction of the carriage, and, after that, rise at any convenient rate sufficient to take up the energy imparted. It is hardly necessary to add that the work done in arresting the recoil will be equal to the work done in obtaining its maximum velocity, and also to the external work of the discharge, so that the determination of the second portion of the recoil will serve to check the first. As far as I know, up to the present, these two distinct

parts of recoil have been mixed up together, and no deductions as to the rate of work in the bore have been made from either of them. When the wave line has been obtained, it is easy to calculate the velocity at each intersection with the centre line. The motion there is compounded of the maximum velocity of the tuning fork and the velocity of recoil. If a tangent be drawn to the wave line at the intersection with the centre line, then the tangent of the angle made with the centre line will be represented by the velocity of the fork divided by the velocity of recoil.

The amplitude of the fork's vibrations is constant throughout, and may be measured on the diagram, the maximum velocity, which occurs when the stile crosses the centre line,

$$\text{is} = \frac{\pi \times \text{amplitude of vibration}}{\text{time of a complete vibration}} = v$$

$$\text{velocity of recoil} = \frac{v}{\tan. \alpha.}$$

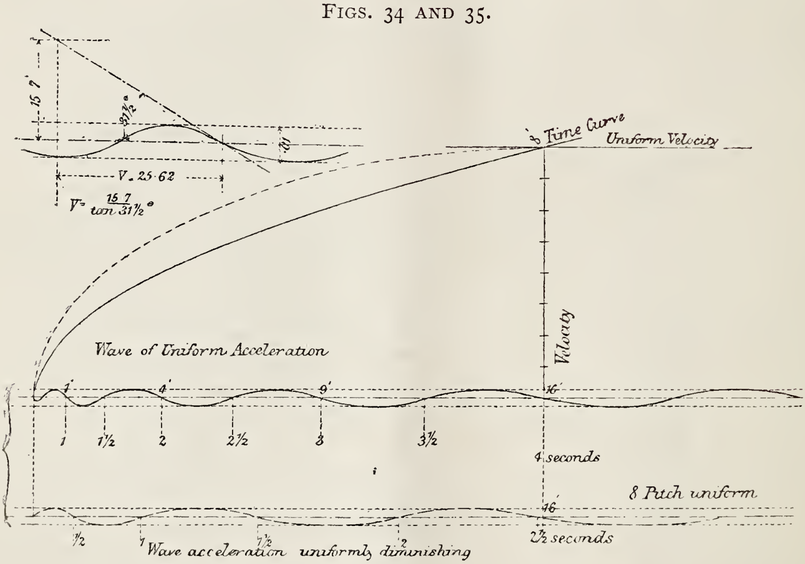
Suppose the amplitude $\frac{1}{100}$ of a foot and the number of vibrations 500 per second maximum

$$\text{velocity} = \frac{3{\cdot}1416 \times {\cdot}01 \times 500}{1} = 15{\cdot}7'.$$

Suppose the curve crosses the centre line at an angle of $31\frac{1}{2}°$, then the speed of recoil will

$$\text{be} = \frac{15{\cdot}7'}{\tan.\ 31\frac{1}{2}} = 25{\cdot}62 \text{ feet per second.}$$ The numerator will be a constant for each instrument.

FIGS. 34 AND 35.



The investigations which I have gone into are intended to lead up to the determination of the pressure of the powder gases in the bore of a gun. These pressures are up to the present unknown, except so far as they have been determined by the unsatisfactory agency of crusher gauges.

Referring to the balance-sheet, you will observe that the external work of the discharge forms nearly 37 per cent. of the whole work of the powder, and the internal work only 2 per cent., or, of the total mechanical work, the external is 94 per cent., while the internal is only 6 per cent., so that any error in estimating the several items of the latter will not sensibly affect the inferences to be drawn from the observations on the first portion of recoil. In the external work, also, the only uncertain item is the energy absorbed in the expulsion of the powder gases, hence if, by means of the Sébert apparatus, we can determine the total external work, we can also determine exactly the uncertain item in our balance-sheet.

The total mechanical work is equal to 28,931 foot-tons, and suppose that this were performed at a uniform rate throughout the stroke of 22 feet, we should have an average push of

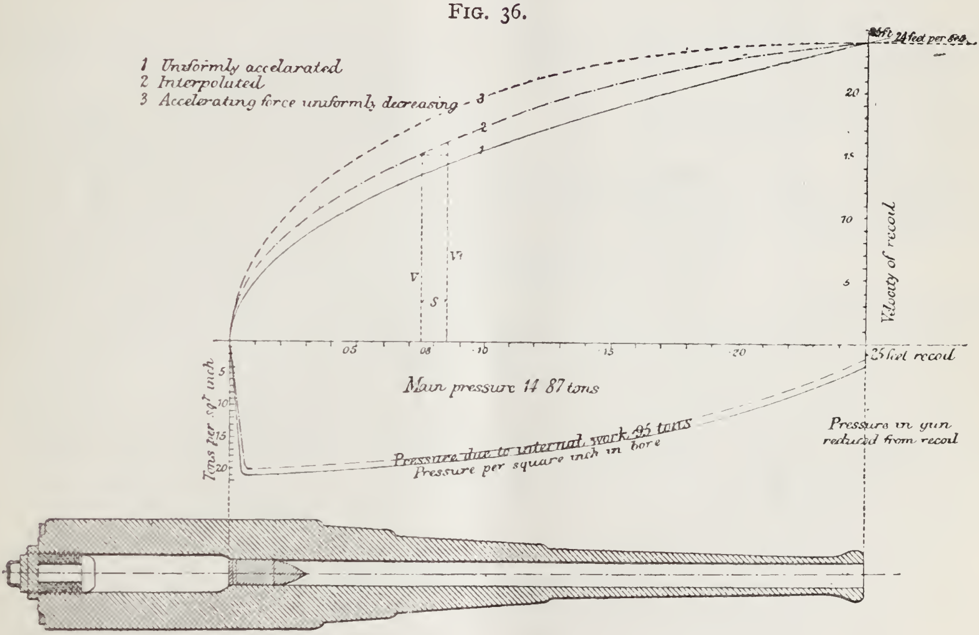
$$\frac{28{,}931 \text{ foot-tons}}{22 \text{ ft.}} = 1{,}318 \text{ tons};$$ dividing this by the area of the base of the shot, 78·54 sq. in. gives an average pressure to the powder gases of 16·78

tons per square inch. The maximum pressure attained by the gases at the commencement of the discharge is believed to be about 18 tons per square inch, though I have reason to think that it must be considerably higher, and the lowest limit, calculating on the assumption that the temperature is 1,700°—about 2·32 tons; so that an empirical curve may be traced, which between those limits, would include an area equal to the work done. If, however, the first part of recoil can be pictured by means of the Sébert velocimeter, and a curve of velocities obtained, it does not matter how irregular the curve may be, the pressures in the gun can be calculated in the following manner. The fact that the velocity of recoil is increasing implies that an impressed force is acting; hence, selecting two points in the recoil at a short measured distance from each other, ascertain by measuring the curve the velocities at the two points, let them be V_1 and V The energy latent in the higher velocity will be $\frac{W}{2g} V_1^2$, and the lower $\frac{W}{2g} V^2$, the difference $\frac{W}{2g}(V_1^2 - V^2)$ must have been due to a pressure acting through the space S between the points $= P S$, hence the pressure—

$$P = \frac{W}{2gS}(V_1^2 - V^2).$$

As we know all the

FIG. 36.



terms of this equation, the pressure P on the carriage will be known, and that will also be the pressure on the base of the bore at the corresponding period of discharge. If we divide this by the area of the bore, the pressure per square inch follows at once. In this way a curve of pressures in the bore may be accurately arrived at.

In addition to the tuning fork, the Sébert machine has stiles fixed to the armatures of electro-magnets, the attractions of which, so long as the current is passing, keep the stiles immoveable; consequently, when the gun recoils, the stiles trace a straight line close beside the wavy line of the tuning fork. The wires from the electro-magnets are, however, carried across the line of fire, one just in front of the muzzle, a shot length off, and a pair through the ordinary velocity screens. As soon as the shot breaks the wires, the armatures leave their magnets, and their stiles make a kink in the line they trace. The relative positions of these kinks, as to time and space are defined by the undulations of the line traced beside them by the tuning fork. In this way the exact moment when the shot leaves the gun is ascertained. If the wave line has reached its maximum pitch before the shot leaves, then the gun is too long; if, on the other hand, acceleration of motion is still going

on, then the gun is too short to absorb all the energy of the powder.

We can make an approximation to the recoil on the assumption that the pressure in the bore throughout the discharge is constant, that the powder-gases and shot are expelled at the same velocity, that the space passed through in the bore is 22 feet, and that the gun carriage weighs five tons, so that gun and carriage together weigh 32 tons. The powder and shot together weigh 800 lbs., or ·357 tons; we assume that they are expelled at a speed of 2,100 feet per second. Then, because of the equality of the quantity of motion, the maximum velocity of recoil will be

$$= \frac{2{,}100\text{ft.} \times \cdot 35 \text{ tons}}{32 \text{ tons}} = 23{\cdot}42 \text{ feet per second.}$$

The time of discharge, which will also be the time of the acceleration of recoil,

$$= \frac{2S}{V} = \frac{44'}{2{,}100'} = \cdot 02095 \text{ seconds.}$$

The space passed through during the accelerated motion of recoil will be

$$= \tfrac{1}{2}\, t\, v \quad = \frac{0{\cdot}02095 \text{ sec.} \times 23{\cdot}42 \text{ feet}}{2} = \cdot 245 \text{ feet,}$$

or nearly 3 inches.

The rate of acceleration during recoil

$$= \frac{V^2}{2S} = \frac{22{\cdot}42^2}{2 \times \cdot 245'} = 1{,}118 \text{ feet per second,}$$

corresponding to the value of g in gravity; hence the accelerating force will be

$$\frac{32 \text{ tons} \times 1{,}118 \text{ feet}}{32{\cdot}2 \text{ feet.}} = 1{,}111 \text{ tons.}$$

The rate of acceleration in the bore of the gun

$$= \frac{2{,}100^2}{2 \times 22} = 100{,}230 \text{ feet per second, and}$$

the accelerating force,

$$= \frac{\cdot 357 \text{ tons} \times 100{,}230 \text{ feet}}{32{\cdot}2} = 1{,}111 \text{ tons;}$$

that is to say, the pressure on the breech, block, and against the carriage is the same, and equal to 1,111 tons, which, divided by 78·54 square inches, the area of the bore, gives 14·14 tons per square inch as the average pressure of the powder gases.

The energy of recoil

$$= \frac{32\,t \times 23{\cdot}42^2}{64{\cdot}4} = 272{\cdot}7 \text{ foot-tons,}$$

which figure is also arrived at by multiplying the accelerating force of 1,111 tons by the space it works over = ·245 feet.

Suppose the carriage, as soon as the maximum speed of recoil has been attained, is made to run up an incline of 1 in 10, it would rise $\frac{1}{10}$ of a foot for every foot of recoil, and would do 3·2 foot tons of work. The resistance of friction would be about 8 lbs. to the ton weight of gun and carriage

$$= \frac{32\,t \times 8 \text{ lbs.}}{2{,}240} = \cdot 144 \text{ tons per foot,}$$

so that the total resistance would be 3·344 foot-tons per foot of recoil, and therefore, the gun will come to rest in

$$\frac{272{\cdot}7 \text{ foot-tons}}{3{\cdot}344 \text{ foot-tons}} = 81{\cdot}56 \text{ feet.}$$

It is very improbable, however, that the pressure in the bore can ever be uniform. Such an assumption is an extreme one, but we may take another extreme view, and suppose that the powder gases act like a spiral spring, the tension of which varies as the distance through which it is compressed. Under such circumstances, the velocity of recoil will vary as the square root of the difference between the square of the full compression of the spring, and the square of the compression up to the point where the velocity is to be determined.

If P = pressure required to compress a spring one foot, S = full range of compression, S_1 range of compression at any other point, W weight moved, and V the desired velocity, the tension of the spring compressed to a distance S = P S, and its potential energy will be $= P\,S \times \frac{S}{2} = \frac{P\,S^2}{2}$. The kinetic energy would be $\frac{W\,V^2}{2\,g}$ and that must be equal to the potential—

$$\therefore \frac{P\,S^2}{2} = \frac{W\,V^2}{2\,g} \quad \therefore P = \frac{W\,V^2}{g\,S^2}$$

At any other point, S_1 feet compression, the energy is the total energy due to the compression S less that due to S_1

$$= \frac{P\,S^2}{2} - \frac{P\,S_1{}^2}{2} = \frac{P}{2}(S^2 - S_1{}^2) = \frac{W\,V^2}{2\,g}$$

$$V^2 = \frac{P\,g\,(S^2 - S_1{}^2)}{W}$$

$$\text{and } V = \sqrt{\frac{P \times g}{W}} \times \sqrt{S^2 - S_1{}^2} = a\,\sqrt{S^2 - S_1{}^2}$$

I have calculated the curves of velocities which will produce a speed of recoil of 24 feet per second, in one quarter of a foot, and have drawn them on the diagram (Fig. 36). The ordinates in curve No. 1, give the velocities due to a uniform pressure. You observe that the curve cuts the line of uniform velocity of 24 feet per second at an angle which indicates that the pressure must cease suddenly when the desired velocity is attained. Curve No. 3 gives the velocities, supposing the force to be of the nature of a spring, and you notice that the line of uniform velocity is a tangent to it, which indicates that the accelerating force ceases to act gradually, and, when the full velocity is attained, acts no longer.

The true velocities lie between these two, and I have interpolated curve No. 2, which will probably not be far from the mark. This curve has no known equation, but I have taken out the accelerating force in six places by the method already described, and so obtained a curve of pressure acting against the carriage, that is, against the bottom of the bore of the gun. Dividing this by the area of the bore, I obtain the pressure per square inch, and by changing the scale of the diagram, so as to make the base line represent the length of the chase, I get a curve of the powder pressure along the whole bore. The maximum pressure comes out about $20\frac{1}{2}$ tons per inch, the minimum $2\frac{1}{2}$ tons, and the mean pressure 14·87. The area of the figure bounded by the curve of pressures will give the external work done; the figure is, in fact, an indicator diagram of the gun, but is still incomplete, for we must add 7 per cent. to the pressures, amounting to nearly one ton per square inch, to represent the internal work, which does not affect the recoil. I have added this as a constant pressure throughout, though it may not be so, but, as you see on the diagram, the amount is small, and will not much affect the accuracy of the result, in what manner soever the pressure may really vary.

I have said that the indications of the crusher gauges, upon which so much reliance is placed, are untrustworthy, my reason for thinking so is because time is an element in the complete action of a shortening or extending movement in a metal cylinder; hence, in order that the indications given by compression may be comparable, the time during which the forces act must be either long enough to allow the whole effect to take place, or, at any rate, the same in all the experiments. Now the compression of the little copper cylinders of the crusher gauges take place in very short and very unequal times. The gauge in the breech is much longer exposed to the actions of pressure than in the muzzle, yet the change of length is compared uniformly with pressures slowly applied, and therefore the indications of the gauges are sure to be too low. I am confirmed in this view by the extraordinary coincidence between the pressures indicated by crusher gauges and those derived by calculation from increments in the velocity of shot as it traverses the bore. This velocity has been ascertained by Captain Noble by means of an instrument called a chronograph, which registers the time of the shot passing certain points in the chase. We have already seen how, from a curve of velocities, the pressure can be calculated; it is found that the crusher gauges indicate the pressures due to the accelerated motion of the shot only; hence, either their indications are erroneous, or else we must conclude that the powder gases have no weight, that there is no atmosphere to displace, no friction of gas check or gases, and no work in producing rotation. This error is by no means a trifling one, for you will see by the balance-sheet that the items I have just mentioned form over 40 per cent. of the whole mechanical work done.

Hydro-pneumatic carriages for disappearing guns furnish a very good means of measuring the intensity of recoil, because it is taken up chiefly by the compression of air. In the carriage for the 6·6-inch gun already alluded to, the calculations for the necessary air pressures were made upon the system laid before you in this lecture; the result of the trials at Shoeburyness indicates that the calculated recoil was realised within two or three per cent., demonstrating that my estimates of the force of recoil are not very far from the truth.

INDIAN SECTION.

Friday, May 8 1885: R. BRUDENELL CARTER, F.R.C.S., in the chair.

The paper read was—

ANCIENT AND MODERN METHODS OF TREATING SMALL-POX EPIDEMICS IN INDIA.

By SURG.-MAJOR ROBERT PRINGLE, M.D.,
Late Sanitary Department, H.M. Bengal Army.

Of all the epidemics which have devastated humanity, that of small-pox seems to be the only one which has been met, and, I may say,

to a certain extent defeated, by rational modes of treatment. In ancient times, inoculation was the means used in the Himalayas to limit the ravages of small-pox, by the production of a mild type of the disease; while within the last thirty years, Jenner's great discovery of vaccination has been systematically, and in some parts of India extensively, introduced, with benefits which have varied in exact proportion to the care and supervision employed in the practice of the prophylactic.

As vaccination requires no detailed description, except where the practice of it in India necessarily differs from that in England owing to the climatic differences between these countries, I shall in this paper dwell chiefly on a description of the practice and beneficial results of the ancient system of inoculation.

It is certainly a striking coincidence that, in this age of Pasteurian research, this ancient practice of inoculation should in so many points so closely resemble that founded on the results of M. Pasteur's discoveries in the case of other diseases, such as splenic fever; and that in this mode of prophylactic treatment, carried on from time immemorial in the Himalayas, we should have what in reality is a cultivated product, employed as a preventive against the liability to a severe spontaneous attack of a disease by ingrafting, and thus imparting the same in a very mild form. As all that I shall hereafter describe is the result of my own personal observation and experience in the Doab—or Mesopotamia—of the North-West Provinces of India, from fifty miles above the junction of the Ganges and Jumna to their sources in the Himalayas, during the past twenty years, it may be as well briefly to allude to the circumstances which have enabled me to enjoy such a series of prolonged and continuous observations on the subject. In the beginning of 1864, I was appointed to the Sanitary Department of the North-West Provinces, and directed to inaugurate a system of gratuitous voluntary vaccination in a country as extensive as England and Scotland, with a population of ten millions, and an average of 500 to the square mile. In the southern portion of this sanitary circle no prophylactic measures, properly so-called, were carried on; on the contrary, the popular religious ceremonials always in practice were often in reality the causes of extensive and fatal outbreaks of small-pox. In the northern portion, however, a practice of systematic inoculation was met with, and it is to this I desire to direct attention. As regards the origin of this system of inoculation, I have been unable to discover anything satisfactory, either as to its probable date, and the locality wherein it could be said to have originated. At first, I was under the impression that the practice had come to India through the Himalayan passes, but further observations have now convinced me that such is not the case, and I am, therefore, led to believe that the practice originated in the Himalayas, but the hopelessness of fixing even an approximate date for this will be evident from the following conversation I had with an old hereditary inoculator. On asking the probable age of his inoculating instrument and of the practice, his answer was so characteristic, that I shall try and give it in his own words. Pointing to a plough lying in a field near, he said "I got it (the inoculating needle from my father, as the owner of that plough got it from his, and my father used the needle, much as the father of that cultivator used that plough, viz., as a means of livelihood." Now, though I am not prepared to endorse the probability of the synchronism of the origin of cultivation and inoculation in India which my informant evidently believed, yet I feel this account of the possible age of inoculation in India precludes the hope of ever arriving at any satisfactory conclusion on the subject; so I may at once pass on to a description of its practice.

The practice of inoculation, for all necessary purposes of discussion or description, may be confined to that met with in the Himalayas, for though the social and religious castes of the inoculators in the plains of Bengal may vary from those of the Himalayas, yet in the practice of their art they are virtually similar, so I shall only now briefly allude to the essential points in which the practice differs, viz., the social and religious observance of the operators. In the Himalayas the profession of inoculators is a hereditary one, and confined to the priesthood, and though inoculators can practice in any portion of the plains of Hindostan, yet they are not permitted to do so in the districts of another inoculator in the Himalayas. A few of these inoculators operate for cataract, and for the removal of vesical calculi; and one of them, when giving me his inoculating instruments, begged my acceptance of those for cataract, and his lithotomy knife; and on inquiry, I found this surgical knowledge, such as it was, like that of inoculation, seemed to have been hereditarily acquired. In the Himalayas the

inoculators are known by the name of "chapawallahs" or markers, and to distinguish them from the vaccinators they were called "Hindustani chapawallahs;" while the vaccinators were "Belattie chapawallahs," *i.e.*, foreign markers. In the plains of Bengal the inoculators are called "Malis," but they are not necessarily market gardeners, as that name would imply, though it is quite possible that it may have some connection with the profession of cultivator, in which in India engrafting as regards fruit trees is of such importance. The "Malis," unlike the Himalayan inoculators, belong to no particular religious or social caste, indeed they are of all castes, except the sweeper or lowest of all; they seem to take up the profession of an inoculator by choice, and no doubt they find it a very remunerative one, in a country where small-pox is an annual visitor. Though the inhabitant of the Himalayas objects to leave his mountains, yet, doubtless, on the visit of some of these inoculators to the plains, a number of Brahmins learnt the art and the requisite religious ceremonies, and took up the practice of inoculation as a profession. Thus it spread in Northern India, though in a somewhat remarkable manner, viz., passing down to Lower Bengal, but leaving the intervening countries north of Allahabad unprotected by the practice. This fully accounts for the 95 per cent. of small-pox marked adults in the population met with in these unprotected countries. As the system of inoculation in Bengal is merely an offshoot of that found in the Himalayas, I shall confine my remarks to the practice in the latter country; premising that my information is gathered from the portion of the Himalayas known as the independent native State of Tirri Ghurwâl, or that portion of this range lying between British Ghurwâl on the east, and the native hill States of Simla on the west. This country as possessing the two most sacred spots to the Hindoo, viz., the source of the Ganges, or Gungootrie, and that of the Jumna, or Jumnootrie, has a peculiar interest to them, and everywhere in India the water from the glacier at Gungootrie is as much prized as the holy food of Juggernauth, and both are readily purchased, often at very high prices. It is from this sacred country that the modern prophylactic (vaccination) has been spread, as I shall show hereafter, by means of the "Lymph Nurseries" "without money and without price," to the lasting benefit of a population counted by millions. Indeed, so remarkable is the power of this modern prophylactic in preserving human life from the ravages of small-pox, that the sources of the food supply for the thousands thus saved (and the number is annually increasing) will, in the not very distant future, be a serious matter for the Government to consider. For if, in the graphic language of the country, each small-pox marked case represents a death from the disease, some idea, and not an exaggerated one, may be arrived at of the appalling mortality from small-pox in the past: and this harvest saved from death has been accumulating for years, not over thinly populated districts, but in countries with an average of 500 to the square mile. As the practice of inoculation is now strictly prohibited, I am happy to employ the past tense in the description I shall give of it. As previously noted, the profession of inoculator was hereditary, and confined to the priesthood, the small-pox matter used in the operation was generally obtained either from the plains of Hindostan, in the form of crusts or scabs, or from a case of small-pox imported into the locality, resulting from exposure to the small-pox contagion in the plains, and due to defective inoculation. The instruments employed were a needle, or, rather a bundle of needles, like those shown, and a brass pestle and mortar. This inoculating instrument was made by fastening together a few needles, generally either seven or three, the former the perfect sacred number, and the latter the mark of Shiva, or the trident, the priests' fork of the Levitical dispensation. These needles were first imbedded in a piece of wax, and then secured by some blue cotton thread, fastened tightly round them. Here I may mention a strange coincidence regarding this inoculating needle. In 1854, I took to India a vaccinating needle, newly invented by Dr. Graham Weir, of Edinburgh, and after having proved its perfect adaptation for vaccinating in India, I reported it to the Government, and the instrument was generally adopted. Ten years after, *i.e.*, in 1864, I found this very needle employed for inoculation in the Himalayas, and in the same way, and from time immemorial; and now Weir's instrument, which I exhibit with three needles, like the inoculating needle, is made by the hundreds, and used by all who have ever once operated with it, and in the hands of my native vaccinators, with a success equal to any series of operations I have seen in this country. To reduce the small-pox matter into a con-

dition suitable for operating with, it was powdered in the mortar by means of the pestle, mixed with a little treacle and flour, and enough water added to make the product assume the consistence of a thin paste. This composition was applied either in this condition alone, or by means of blue cotton previously dipped into it, and bound by blue thread over an abraded surface, produced by deep scratches with the inoculating instrument, at the base of the right thumb in males, and the left in females. When the supply of this small-pox composition admitted of it, a small quantity was given in the form of a bolus. Small-pox matter in the fluid form as lymph was rarely used, probably owing to ignorance as regards its activity, and the difficulty the inoculators experienced in conveying it, when compared with the facility of carrying a few small-pox scabs put into a hollow bamboo, closed at both ends with cotton. The failures attending the operations with this compound were often very numerous, for when the demand was great and the supply small, treacle and flour too often made up what was wanting in small-pox matter; and this, combined with the rough mode of applying the matter, and the small quantity of it, frequently resulted in many of the travellers contracting small-pox on their visits to the plains with Ganges water for sale.

Most elaborate religious ceremonies were gone through, and various religious requirements were strictly enjoined, which served to keep the cases operated on at home, and thus in reality placed them in a strict quarantine, though this unpleasant condition was disguised under the compulsory performance of various religious observances.

Religion seems to have been so mixed up with the whole practice of inoculation, that it partook more of a religious ceremony than an exhibition of medical skill; while the goddess of small-pox, "Seetla" by name, was propitiated by gifts to her priests and at her shrines, and special hymns were sung in her honour. The following is a translation of one of these hymns:—

"Visit, oh! Seetla, this secluded dwelling; stand at the door,
And give this child the gift of health.
Much have we worshipped thee for its sake before its birth:
We have worshipped thee at Pryag [Allahabad] and Juggernauth,
And bathed in the sacred Ganges at Hurdwar,
And have made obeisance at all thy shrines.
We will paint thy face with 'roree,' and pour into thy lap sweet smelling spices.
Then go, and swing thyself happy on thine own neem tree,
That so all in this house may be happy likewise."

When the fever ran high, and the symptoms were critical, the following remarkable ceremony was often performed. A goat, with its forehead coloured red with "roree," was brought to the side of the sufferer, and the hands of the patient were placed on its head, the goat was then taken away to the jungle and released.

I may, perhaps, here briefly describe the religious ceremonies performed in the southern portions of my sanitary circle, and as no inoculation was practised, and no attempt made to isolate the cases, or diminish the force of the contagion thus generated, it need not be a matter of surprise, therefore, that these "Seetla poojahs," or festivals in honour of the goddess "Seetla," were the means of lighting up epidemics of small-pox such as would have made the country uninhabitable for Europeans had they not been protected by vaccination; for even Britain could not have stood the annual drain which would have been made on her population, both for the civil and military branches of the service. As it is, this wonderful immunity enjoyed by Europeans, and especially as seen among the European troops, has been one of my most effectual proofs to the natives of the benefits of vaccination. The cities of Agra and Meerut are the great centres of the worship of the goddess of small-pox in my sanitary circle, and when a case of small-pox appears in a family, notice is too often sent to the relations, friends, and neighbours, a party, chiefly composed of the females of the families, is made up, and a lucky day having been selected, it is kept as a strict holiday. Of course children and infants accompany their mothers on these occasions, and all, including the cases of small-pox, go to the shrine of "Seetla." Here (as I have seen) the cases of small-pox get mixed up with the children as yet free from the disease, and as a natural consequence it rapidly spreads. On one occasion at Meerut, I had been vaccinating to a considerable extent among the children born in the hot and rainy seasons (for reasons given hereafter), as a few cases of small-pox had appeared, but so anxious were the mothers and female members of the families in many cases to have the excuse for taking, or rather making, a holiday, that I saw children with the vaccination in every stage around the shrine of the goddess; while others, in an almost unrecognisable condition from small-pox, were presenting gifts to propitiate the divinity. When the disease shows a tendency to be confined to a locality, the following cere-

mony is often performed, in the hope of removing the evil spirit of small-pox, or inducing it to leave. A quantity of small-pox scabs are collected, and placed in an open earthenware saucer, with a little flour, spices, &c., and deposited where two of the most frequented roads in the locality cross each other, in the hope, that a passing wheel may break the saucer, and scatter the scabs, and with them the spirit of small-pox. The cross roads, at the gate of the magistrate's office in Agra, used to be a favourite spot for these saucers to be placed at night, accompanied with the necessary religious ceremonies. With the exception of the Himalayan portion of my sanitary circle, no prophylactic measures of any kind were adopted to check the spread of an epidemic of small-pox, and when it is considered that small-pox is allowed to be the most contagious of the eruptive fevers, these religious gatherings to propitiate the goddess of small-pox could only tend to propagate and disseminate the disease broadcast over the districts, in a manner it is impossible to understand in this country, and yet, out of the 10,000,000 in my circle, more than 9,500,000 were subjected annually to the full force of this contagion.

I now come to a description of the visible benefits which resulted from this system of inoculation, practised from time immemorial in the Himalayas. In illustrating these benefits, I think the best plan will be to compare the visible evidences of small-pox epidemics, as seen in the small-pox-marked adults met with in the plains of Hindostan, where inoculation is not practised, or vaccination is unknown or rejected, with the results of this system of inoculation in the Himalayas, as seen among the adult population. As in this country, where inoculation is unknown, and small-pox marked faces are even rarer than they are in the Himalayas, this remarkable difference between the visible eruptive results of spontaneous and inoculated small-pox may be difficult to understand, I think I cannot do better than illustrate it, not so much by figures, as by what I may term visible facts.

The following shows the results of an inquiry carried on for certain years, between 1861 and 1872, in certain jails in the North-West Provinces of India, where the records on the subject of small-pox had been carefully kept:—

Total number of persons examined.... 268,445.

			Per cent.
Number exhibiting visible marks of small-pox	228,964	or	85·29
Prisoners with doubtful marks of small-pox	20,480	,,	7·62
Unprotected................	12,215	,,	4·56
Inoculated	4,233	,,	1·56
Vaccinated	2,553	,,	0·95
	268,445		100·00

My experience, the result of twenty years' personal and special observation of the subject, in the upper portion of the Doab, or Mesopotamia of the North-Western Provinces, is such, that I consider 95 per cent. of the adult population, whether of the criminal or non-criminal class, have visibly suffered from small-pox, and while 90 per cent. will show the marks of the disease on the face, the other 5 per cent. will also be found to possess traces of the attack, if the examination is sufficiently carefully conducted, and the 7·62 per cent. entered as exhibiting doubtful marks of small-pox, in a country where chicken-pox is a very rare disease, would, doubtless, come under this former class, had there been time, on admission into the jail, to have made a sufficiently careful examination. Had small-pox been permitted to devastate the Himalayas as it has the plains of India, with the limited population in the former, and the annual opportunity of importing the disease by means of the Ganges water sellers visiting the plains, even as far as the native State of Gwalior, it is difficult to see how the population of the Himalayas could have been maintained; as even now, with small-pox virtually deprived of its mortality, the increase of population, from causes it is unnecessary to allude to here, is scarcely perceptible.

While alluding, therefore, to this remarkable absence of small-pox-marked cases in the Himalayas, where all above forty are inoculated, I would suggest the following as a possible, nay probable, explanation of the occurrence, viz., that it is due to the effect produced by what, for want of a better term, I may describe as the accidental cultivation of the small-pox virus, not in prepared soil, but in the human system. For the inoculators, once the inoculated disease was originated, used the dried-up small-pox virus or scabs collected from their own inoculated cases, and not from those spontaneously attacked with small-pox in the plains of India. Thus the process of small-pox cultivation was carried on through many transmissions, till the cultivated product resembled in its action cowpox lymph, and only produced local symptoms at the point

of insertion, or else so rarely a small-pox eruption as to make its appearance quite exceptional. I enter thus fully into these details, as they seem to me most important, exhibiting as they do the real benefits of this ancient method of treating small-pox epidemics in India—where the disease may be termed a universal disease and an annual visitor, so much so that it is very unlikely (in a country where there is no approach to isolation of the cases—on the contrary, as before pointed out, they are collected during the "Seetla" festivals)—a child will, unless inoculated or vaccinated, escape an attack of the disease during the first ten years of life. So universally prevalent, and so terribly fatal among children, is small-pox in India, that a parent will not calculate on his children, nor leave any money to them, till they have recovered from the usual attack of small-pox. In the sacred city of Muttra, with a population of 44,000, small-pox carried off in 1863, in two months, 3,500 children; and yet, twenty years of careful and systematic voluntary vaccination, without either re-vaccination or small-pox hospitals, imparted such immunity to this city, that in 1883, a year of equal small-pox prevalence, not one fatal case was recorded from this disease. In 1864, I began the system of voluntary vaccination alluded to before in this sacred city, and had to contend against indifference, suspicion, and religious prejudice, but vaccination triumphed at last, and I can point to the immunity of 1883 as exhibiting the success of the modern method of treating small-pox epidemics in the plains. In the Himalayas it was quite different, there I had to contend against what was in reality an ancient and successful method of overcoming small-pox epidemics, and the most serious charge I could bring against it was that the practice kept up the disease. In supplanting inoculation, therefore, by vaccination, I had no easy task to perform. I was not long, however, in having an opportunity of showing the two prophylactic systems in practice, for hearing that an inoculator was at work in a village not far distant, I went to the spot, and vaccinated in the one nearest that in which inoculation was being practised. The inoculator on this occasion was most unfortunate in the results of his operations, perhaps owing to all the cases having been inoculated with matter from spontaneous cases of small-pox, for there were six deaths out of the sixty operated on, and several were very severe attacks of the disease. Though this experiment satisfied the villagers of the immediate benefits of vaccination, when they saw all the vaccinated cases in good health from the neighbouring village, where all had enjoyed the fullest freedom and intercourse with other villages, while they had been in strict quarantine, yet it gave them no proof of the future benefits in the immunity they would possess from small-pox if exposed to the contagion of the disease which I claimed for all these vaccinated cases, without the repetition of the operation at any future period. Time alone could prove my assertions, and ere I left India, after labouring for twenty years in Tirri Gurwhâl in the Himalayas, the evidence of this immunity, alluded to hereafter, was overwhelming, and inoculation is now forbidden by the Maharajah of Tirri, and a fine inflicted on those practising it. The secret of my success lay in my impressing the fact on my native subordinates that our work must stand on its quality not its quantity; the latter would follow if the people were satisfied with the former—re-vaccination was not to be thought of, and with this object in view, my vaccinators were enjoined not to leave any unsuccessful cases in a village. If my triumph, therefore, is complete, I owe it to my native subordinates to record here the honest, faithful, and diligent manner in which they carried out my orders as greatly contributing to this successful result. Here also I would distinctly and emphatically state that, had I believed in the necessity of re-vaccination, I should never have taken the leading part I did in the Himalayas on the subject of the best prophylactic measures for small-pox; and for twenty years have devoted my entire energies to supplant an ancient and justly prized system of inoculation—without the repetition of the operation, which might have been much improved by care and method—by vaccination with re-vaccination; as, in my opinion, improved inoculation would be infinitely superior to vaccination with re-vaccination in any country, and much more so in one like India, with, in my sanitary circle alone, an annual birth-rate of half a million. Only during the last few years had my vaccine operations reached half the birth-rate, with two hundred operators, working for five months at nothing else but vaccination; and to think of re-vaccinating before I had reached half the birth-rate, and that then, year by year, the number requiring re-vaccination was increasing, according to the modern theory of the practice, till to attain immunity,

I should have had to go over once all I had done in twenty years, and some of it twice. The bare idea of this was too much for me, and as I could find nothing in physiology nor pathology to support it, I decided upon taking my stand on quality not quantity, and declined to re-vaccinate, and accepted the consequences of incurring the displeasure of the then head of my department. Twenty years have proved I was right, and the present condition of the sanitary circle of that late head of the department, alluded to, is, in the words of the Government, a standing proof that re-vaccination, as practised in the British Ghurwâl and Kumaon Divisions of the second circle of the North-West Provinces, is something worse than a failure. On now looking over the work of these twenty years, I feel what I trust I may without self-laudation describe as, a pardonable pleasure, not at what I have been enabled to do, but at the wonderful approach to perfection which Jenner's great discovery has attained, not by means of statistics, but by visible facts, in a country where small-pox is worshipped as a goddess, and where religious prejudice, apathy, fatalism, and last, but not least, suspicion, seemed to combine to prevent the scheme even getting a trial. True I took up the work before it had quite recovered from the disgrace attendant on the exposure of a system of false returns, so flagrant that the magistrate of one district wrote the following regarding it:—"I regret to record my conviction here, that these numbers are a wholesale imposition. . . I would simply protest against these figures forming any data in favour of any system of vaccination." Nevertheless, I was confident that careful and systematic vaccination must, in the end, triumph, if carried on with reference to quality, not quantity, in a country where the annual return of small- pox gave all an opportunity of seeing the real benefits of good vaccination. At first, only the children of the lowest castes were obtainable for vaccination, and the girls in villages under the inspection of the officers carrying out the Female Infanticide Act; these girls, sad to relate, were submitted to the operation in the hope that they would die from its effects, and thus save the family the risk of dishonour inseparably associated with unmarried daughters among certain high-caste families in India. The very opposite, however, was proved to be the result, and while the boys in these families were swept off in numbers by small-pox, the girls lived; these tactics had, therefore, to be changed, and now, as I have pointed out, these girls are left unvaccinated in the hope that they might contract small-pox and die, a circumstance to which I lately drew the attention of the magistrate of Saharanpur. One of the greatest difficulties to be overcome, however, in this system of gratuitous voluntary vaccination, which I inaugurated in the beginning of 1864, was to remove the suspicion which in eastern countries is always attached to any gratuitous voluntary scheme; and it was reserved for the priests of Benares to supply an explanation of the reason of these two strange conditions, gratuitousness and voluntariness, in what was ostensibly for the public good. The story was the following. Some of the priests of Benares (among whom are many deservedly respected for their learning) gave it out that the secret of these conditions lay in the circumstance that there was an old prophecy that a black child would be born with white blood, who should rule India, and turn the English out, as they expressed it, and it was with a view to find out the advent of this child, that the Government had given orders "to scratch the arms of the children." But even this has been lived down, and this purely voluntary scheme of vaccination, practised on its own merits entirely, has so satisfied the Mahomedan member of the Viceroy's Council, the Honourable Syed Ahmed, C.S.I., of the real benefits it confers, that, though in 1864 as the chief Mahomedan in the district of Alighur, with a population of over one million, if he did not actually oppose the scheme, he cared very little about it, yet eighteen years after he brought in, and carried through the Council a Bill for compulsory vaccination in certain localities, and under certain conditions; the result, as he said, of the visible benefits of vaccination in the district of Alighur. So much for the national difficulties with which vaccination has to contend in India, but there are others equally difficult to overcome, viz., those of climate. These may be summed up in the effect produced by the high temperature met with in the plains of India, between April and October, for, with the exception of the tracts of India, which are directly affected by the sea breezes, and those above an altitude of 5,000 ft., the vaccine vesicle cannot be kept up in that country throughout the year in the perfect state in which it should be, either to impart its full benefit to the case operated on, or be the means of extending it to others. Here is a fact, I believe, but imperfectly known in this country, and which would seem at first sight such as would prove fatal

to any national system of vaccination. This, too, has been overcome, and by combining the northern and southern portions of my circle in maintaining the lymph, I have been enabled in certain towns and cities, in all cantonments in my sanitary circle, and in one district where vaccination has been fully and freely accepted, to virtually exclude small-pox, and this without a single case of re-vaccination, or the erection of one small-pox hospital, as far as my vaccine work required its construction. The following is the system I have adopted to overcome this serious climatic difficulty, and the testimony borne to its success in 1883-4, in public documents was most gratifying, when, though suddenly and unexpectedly called upon for a supply of vaccine lymph, it admitted of a virtually unlimited supply of good vaccine lymph ample for the requirements of countries with a population of upwards of thirty millions, though the season's supply for my own circle was for only half that number. If I exclude the Himalayan portion of my circle, vaccination can be satisfactorily carried on for only five out of the twelve months in the year, *i.e.*, from the middle of October till the middle of March. I speak from the continuous experience of twenty years, and am perfectly satisfied that vaccination carried on for a longer period than this, among the native population in the North-West Provinces and Oudh, will only result in a spurious protection, and by the deterioration of the vesicle from the heat will most probably produce such consequences as would ultimately be apt to prove fatal to the whole scheme. By the middle of March, therefore, all vaccine operations in my circle are closed in the plains, and thus favourable weather for insuring the healthy healing of the vaccine cicatrix is secured, a most important item in a voluntary scheme, as a number of vaccine cicatrices converted into large ulcerating surfaces, owing to the heat, dirt, and flies of the approaching hot weather, and taking weeks to heal, would seriously interfere with the success of the voluntary scheme in the following year. A few tubes of the lymph from the plains are in April taken to the Himalayas, and, during the last two years, I succeeded in retro-vaccinating from the calf, by Brahmin inoculators taught vaccination, in Brahmin villages, and vaccinating Brahmin children, while Brahmins held the calf. This has made my circle quite independent of English vaccine lymph, and firmly secured the acceptance of vacination by these high caste Brahmins, who can now look to the cow, not only for the to them great necessary of life, milk and butter, but also as the source of the medicine, as they term it, which protects them from the vengeance or anger of "Seetla," as every epidemic of small-pox is viewed by them as an indication of her displeasure, and a punishment she inflicts. To collect the vaccine lymph in the Himalayas for the operations in the plains in the middle of October, I have been obliged, owing to the paucity of the population, to divide the country into five districts, so as to admit of a sufficiency of children from whom to collect lymph, and by working from east to west, and taking one district each year, I have thus a sufficient supply of children from whom to collect as much lymph as I require. I have termed these districts my "Lymph Nurseries," and, though I felt that these children up to a few years of age were running a certain amount of risk in this unprotected state, yet, owing to the isolation of the locality, I considered they were, comparatively speaking, not at all likely to suffer from imported small-pox. In 1883, however, small-pox contagion and infection were brought into one of these "Lymph Nurseries," in the form of small-pox scabs among the sugar brought from the plains (no sugar-cane growing in the Himalayas), owing probably to these crusts being swept up from the floor with the sugar sweepings in a village where small-pox was raging; for, as I said before, there is no isolation thought of in these villages, and when children can move about, they may be seen with the disease in every stage of healing. In passing, I may remark, this circumstance will, I think, afford a good example of the test vaccination has to withstand in India. Before my vaccinators could reach the villages (for the disease broke out in more than one, as this contaminated sugar had been received into several), the cases were, unfortunately, rather numerous. However, the vaccinators were amply supplied with vaccine lymph, and vaccinated all the children requiring the operation, and the outbreak was at once stopped; though, I regret to say, some of the unvaccinated children died, and there were some fatal cases also among the inoculated, but not one among the vaccinated cases of the previous nineteen years. This circumstance completely established the credit of vaccination, and the guarantee I held out in 1864 was fully realised in 1883. To show how fatal such an outbreak may prove, I may

mention that I saw in the Himalayas, in 1865, in a large village, what I can only call a gap in the population, *i.e.*, an almost entire absence of children between the ages of six and twelve years, and this though there appeared no want of younger and older children for vaccination. On asking the reason, I was told that the few children before me, between the ages I have given, were all that had escaped from an outbreak of small-pox which had occurred some years previously. Such, I felt could never occur again; but small-pox contagion admitted by means of scabs among the sugar is more difficult to prevent. But, should such ever happen again, I made arrangements by which the case can be isolated till the vaccinator arrives; and as it can only be among very young children, this isolation can be made effective.

The vaccine lymph collected in the "Lymph Nurseries" is sent to the plains in time to begin the vaccine operations in hundreds of localities at once, at the end of October, and when the vaccinator has established the vaccine vesicle, if he loses it, and applies for lymph, he must either be ignorant of his duties, or unfit to be trusted to perform them alone. In supplanting inoculation by vaccination, there was one point in favour of the former which, fortunately for me, I was asked neither to explain nor to defend; as regards that point, in the plains of India certainly, though not so much in the Himalayas, inoculation was superior to vaccination. I allude to the fact that the former can be practised throughout the year, while the latter only for the five cold months, viz., from the middle of October to the middle of March, and further, at the time of the year, viz., from April to September, when small-pox is annually most prevalent, vaccination cannot be practised, while inoculation can. This, in the case of the children born between the 1st March and the end of October, presents difficulties in the way of vaccination which careful and extensive work can alone reduce, though it cannot overcome it entirely. It is not often that small-pox epidemics occur in the cold weather months, when vaccination is alone practicable, but when they do, the natives now gladly accept its benefits, but, during the past twenty years, I have only witnessed three cold weather epidemics, which were due no doubt to a deficiency in the rainfall permitting, by the diminished amount of moisture, the small-pox contagion in the form of crusts to remain active through the months of July, August, and September, while a normal rainfall, on the other hand, reduces if it does not almost entirely extinguish this vitality, by supplying the moisture which, when combined with heat, aids in the death of the small-pox virus by rapid and complete decomposition. It is owing to this circumstance that the connection between famine and small-pox epidemics is due, and in a country like India, where millions are living on the borders of scarcity, a deficient rainfall, which produces famine rates, also maintains the vitality of the small-pox virus scattered over the country.

Such is the system of the modern prophylactic for small-pox, which I inauguarated in 1864, on the basis of quality not quantity, to supply the place of religious ceremonies and the ancient practice of inoculation, and I am perfectly satisfied that nothing but the grossest ignorance in operating, and culpable carelessness in supervision, will ever disturb this system, either in the Mesopotamia of the North-West Provinces, or the independent State of Tirri Ghurwâl. I am obliged to qualify my statements as above, for the inexcusable negligence in supervising the work of the vaccinators, and the perfect travesty as regards re-vaccination of the past few years, according to the Government ruling in the case, robbed the districts of Kumaon and British Ghurwâl, in the second sanitary circle of the North-West Provinces and Oudh, of nearly all the immunity they enjoyed some fifteen years ago, and compelled the Government of the North-West Provinces and Oudh to place on record the fact that, "in the Kumaon Division also, a practice of returning secondary vaccination as primary was discovered," and that "it is then impossible to say to what extent the population of the circle [about 17,000,000] has been protected against small-pox."

It is in no spirit of self-laudation that I write thus, but in one of self-protection, for I know perfectly well, that nothing but a strict conscientious supervision and enforcement, at all costs, of veracity in the returns, and superiority in the work, will keep my late sanitary circle in the condition in which the Government, in 1884, recorded it to be, when I made it over to my successor. Vaccination must be judged by its results, not in statistics, but in visible benefits, and any system of vaccination, therefore, whether voluntary or compulsory, when carried on locally for any series of years to such an extent as to approximate with recorded successful vaccination, the birth-rate, *i.e.*, ex-

cluding the proportion of children that die during the first three months of existence, and which fails to exclude small-pox in any but a few isolated cases, is defective in one of two most important conditions, viz., in the veracity of the returns, or the quality of the vaccination. I would admit no sheltering behind the shield of worn-out or exhausted protective power, due to the time which has elapsed since the primary vaccine operation was performed in infancy, or the neglect of re-vaccination. The disgraceful disclosures in the second sanitary circle of the North-West Provinces and Oudh, publicly exposed in 1883, not only show this in a remarkable manner, but also what may be expected when there is a tendency to sacrifice too much to expediency. The second sanitary circle in the North-West Provinces, which, in 1863, was alluded to in public documents as the pattern circle of vaccination in India, and was fixed upon as the model to be aimed at by all others, and the first (my late) circle which was in that public document, and year, held up to universal reprobation, have in twenty years changed places, and the vaccination in the second circle has been stigmatised by the Government of India in a public document, in 1884, as a "wholesale fabrication of returns," which is not very unlike what was recorded of the first circle in a public document in 1863.

My object in giving this public prominence to the subject of these instances of failure and success in vaccination is because I am satisfied, that what is termed the deterioration in the protective power of really successful vaccination, which has led to the almost universal adoption of re-vaccination, a practice which, in my opinion, as previously stated, cannot be supported either by physiology or pathology, is due to the carelessness, or, it may be, absence of proper supervision; the employment of stored lymph, for which no one is directly responsible; the inferiority in the skill with which the operation is performed, and the ignorance of the true and unchanging characteristics of a true vaccine vesicle; and not to the deterioration, or the exhaustion by time, or constitutional changes, of truly successful vaccination, when carried on from arm to arm, and in such a manner that the vaccinator is alone answerable for the quality of the lymph, and cannot shift his responsibility on the National Vaccine Institution, or other source of vaccine lymph supply.

In conclusion, I would only remark that, in the home of that ancient prophylactic for small-pox, viz., inoculation, that which once was a voluntary scheme of vaccination, introduced by me with great difficulty in 1864, has within twenty years become a gratefully accepted benefit, and the Maharajah of Tirri Ghurwâl has been so satisfied with this modern prophylactic, that, in addition to prohibiting, under severe penalties, the practice of inoculation, he pays from his private purse the entire cost of the present scheme of vaccination, amounting to £50 annually.

On the occasion of my farewell visit on leaving India, in open durbar, the Maharajah thanked my native subordinates and myself for our work, and placed it on public record that he had accepted vaccination for his subjects, and set the example by having his son and heir vaccinated. I taught the sons of the old hereditary inoculators the practice of vaccination, and they were classed among my best operators, and are now employed, not only in the Himalayas, but also in the plains at the foot of the range, in spreading the benefits of vaccination; and Tirri Ghurwâl now enjoys a protection from small-pox such as few countries can claim, and all without a case of re-vaccination, or the erection of one small-pox hospital.

In closing, I would desire to express my sincere thanks to the Council of the Society of Arts for giving me an opportunity of preserving among their valuable records this short description of an ancient prophylactic measure for the preservation of life during small-pox epidemics in India, which, though it had some drawbacks, yet conferred upon the community where it was practised a wonderful immunity from the ravages of the disease, the visible proofs of which will become less and less as years roll by and as vaccination spreads its benefits over the plains of Hindostan, until at last the remembrance of this ancient and remarkable method of treating epidemics of small-pox in India will be forgotten.

DISCUSSION.

The CHAIRMAN said everyone must have listened with great interest and pleasure to Dr. Pringle's graphic account of the great work he had carried on in India, and the successful results he had obtained. The paper embraced questions of widely different kinds, for some of which that Society afforded no fitting arena for discussion. There were, in this

country, people who were unacquainted with, or doubtful of, or disbelievers in, the benefits of vaccination; but he would point out that all these were distinctly medical questions, which might be debated with great interest and enefit in a medical society, but were not questions with which the time of that Society could be profitably occupied. The remaining portion of the paper dealt in a great measure with a subject which fell eminently within the sphere of that Society, viz., the question of organisation for the purpose of extending to a large community the opportunity of availing themselves of a particular course of treatment. On that question he should be happy to hear any observations, especially from gentlemen who might have had experience in India, or in other countries where there were analogous conditions.

Mr. MORRISON asked how Dr. Pringle accounted for the immunity from small-pox in Keighley and Leicester, where there had been practically no vaccination for some years?

The CHAIRMAN said they could not ask Dr. Pringle, on the basis of his Indian experience, to account for what had happened in England; besides which, the question rather transgressed the limit which he had laid down.

Dr. HAUGHTON asked if the discussion were to be limited solely to Indian organisation, because, if so, the number of gentlemen capable of giving their experience would be very limited.

The CHAIRMAN said this was a meeting of the Indian Section, which dealt exclusively with Indian questions, and it would be out of place to discuss organisation, unless it had reference either to India or to countries similarly situated.

Dr. HAUGHTON said there were general principles covering a large field involved in this paper, and if it were published in the *Journal* without any debate, he feared it would be assumed that the Society was responsible for their being correct.

The CHAIRMAN said he believed the Council did not assume to itself any responsibility for the opinions expressed by gentlemen who read papers. Those opinions went forth on their own merits, and he thought the observation which he had ventured to make, that it would not be desirable to enter on a discussion of certain questions on that occasion would sufficiently explain the non-appearance of any comments such as Dr. Haughton referred to.

Mr. MARTIN WOOD said he had known the Indian Medical Service under many different phases, and was acquainted with several gentlemen who had been members of the Vaccination Department. It was in later years that they had been described as the Sanitary Department, though of course they had always been promoters of sanitation, because a medical man could not go up and down the country, mingling amongst the people, as the vaccination officers did, without using his influence to improve their habits, customs, and conditions of life as far as possible; and in that way, quite independent of any question of dealing with small-pox, the efforts of the members of the department had been very useful, and had contributed in many incidental ways not only to the reduction of the mortality from small-pox, but from many other diseases. He had not noticed the date when Dr. Pringle spoke of his having introduced calf lymph; but in 1868, at Poona, he saw Dr. Blanc operating on a calf in that way, and for some years past nearly all the vaccine used in Bombay had been from the calf. As they could not go then into the medical aspect of the question, he trusted some members might send to the *Journal* hereafter statistics which might be necessary to complement the arguments in the paper. Dr. Pringle had not given statistics of small-pox mortality in recent years, though they were always classified and arranged in the Indian returns. There could be no doubt that there had been a diminution of small-pox and its visible effects, but whether that could be attributed so largely to vaccination as Dr. Pringle claimed, was one of those questions which required to be carefully investigated. There had been many changes and improvements in Indian medical experience and in the aspect of various diseases during the last twenty or thirty years, which required careful observation in order to trace their cause and connection. It was very interesting to see how Dr. Pringle had vindicated the practice of inoculation, which had been frequently denounced by the English medical profession as an utter barbarism, whilst he seemed to trace in it a vein of true science; and it was evident there was a certain similarity between Pasteur's methods and the inoculation practised in the oldest native medical system in India. Many modern discoveries or adaptations in medical science could be traced back to ancient practices in India. Allusion had been made to the popular opposition to the practice of vaccination in this country of late years. That opposition had not manifested itself in India as yet, nor did he think it was likely to occur. If, however, one thing was more likely than another to produce it, it would be the institution of compulsory vaccination. Several movements had been made in that direction, but, except in isolated cases, it had not been adopted, because it would be seen that if the matter had been put in that form, the old opposition, which was now passive, would become active, and vaccination itself would be largely prejudiced. The paper was very suggestive with regard to the question of organisation. He could remember the time when vaccination

was over-organised, and when the members of the Department seemed to spend their time wholly and solely in vaccinating and counting up their cases. They had now gone beyond that, and a sentiment of public usefulness and zeal for general sanitary reform had been extended amongst them. He would repeat that the Indian Medical Service had conferred inestimable benefits on the country, and of that Service he believed Dr. Pringle had been one of the most notable instances in recent times.

Dr. PRINGLE, in reply, said it was only lately that the Sanitary Department had received that name; but a medical officer travelling about the country on vaccination duty took very great care to look to sanitation wherever he went. That had always been his practice. A wealthy native left a large sum of money to dig wells every two miles along one of the great roads of India—the Grand Trunk Road—with which the name of Lord Dalhousie will ever be attached. This road went through his district for 250 miles, so that there were a large number of wells there, and on inspection he found that nearly the whole of them contained water more or less in an impure state, due to circumstances which were quite capable of improvement. Though he was not then (nearly fifteen years ago), strictly speaking, in the Sanitary Department, he at once had this attended to; the wells were cleaned out, with no doubt great benefit to the general health, and particularly in that of the troops who had to use this water in or near the encamping grounds. With regard to the subject of calf lymph, he had only used it for three years. One officer tried it before, but it created such a bad feeling that it was given up as being impolitic. In this country one could hardly understand the great prejudice which had to be overcome in this matter, owing to the sacred character of the cow in India. The way he managed was this, he got the Brahmins together, and explained the subject, and asked them to allow a calf to be vaccinated for the benefit of the people. He told them he did not wish to give the animal pain, and persuaded a Brahmin vaccinator to do it, and thus the difficulty was got over. It was done in the most gentle way. He told them they would not hurt the calf more than it would hurt itself in getting through a hedge. Even then the Brahmin objected because the animal kicked its legs a little, and he said it was in pain; but he removed this objection by telling them that they generally tied the cows' legs when they were milked, and pointing out one whose legs were marked with the cord, he added, surely you hurt that cow, and he heard no more argument on that point. With regard to the statistics of vaccination, he must say he received them with the greatest possible hesitation. It was very simple to record "successful," "successful," but when people talked of the whole birth-rate being vaccinated, and yet small-pox was not stamped out, he must beg leave to question the quality of the vaccination. He considered that, what the country had a perfect right to demand, and what he believed himself that the Government might have demanded from him, if he had sent a return that the birth-rate in a certain town or district was successfully vaccinated, and an outbreak of small-pox occurred, that he should be called upon for an explanation. In one instance he heard of a case of small-pox in a place where all the clothes of a large military depôt were washed. He went to the spot, and found children covered with small-pox running about amongst the clothes. He could fancy what a state of alarm that would cause in England, but the people were vaccinated, and no one took the disease. In another case a servant left his master's children to go to his own house, and there he was seen nursing his own child, who was covered with small-pox. That was the test vaccination had to stand in India. He looked upon small-pox hospitals as the greatest sources of danger to the country, for it seemed to him impossible to prevent diffusion of the contagion. The scab was made by nature for the purpose of seed-like disseminating the contagion, and if you shut the door quickly, a small-pox scab might be blown across the room. With regard to inoculation amongst the Hindoos, there was no doubt that what they had learnt regarding the cultivation of the virus was accidental, and if they had taken the lymph instead of the dried matter, they would have succeeded far better. Inoculation, carefully practised, was incomparably better than no protection at all. Supposing there was a case of small-pox on board ship, and there were a number of unvaccinated people on board, and no vaccine lymph, he would certainly inoculate them, and give them a mild type of the disease, rather than run the risk of their having a severe attack, and dying. With regard to compulsory vaccination in India, it was settled in this way. The Act could not be carried into effect in any place except by the express wish of the majority of the representatives of the people on the local committee, and generally on these committees there were always fifteen or sixteen natives to four officials. Compulsion could not be carried out without public notice, and the basis would be, because vaccination was neglected to such an extent that the public health was in danger. He was very grateful to the Society for allowing him to read this paper, giving an account of the old practice of inoculation. He had in his hand a book which he found in India, the original letters of Lady Mary Worthy Montague, describing the practice of inoculation. That book must have gone out in one of the old East Indiamen about the year 1721, but the knowledge of it, as acquired by practice or from observation, had completely disappeared in this country, and such would soon be the case in India.

The CHAIRMAN then proposed a vote of thanks to Dr. Pringle, which was carried unanimously.

TWENTY-FIRST ORDINARY MEETING.

Wednesday, May 13th, 1885, E. L. BECKWITH, Prime Warden of the Worshipful Company of Fishmongers, in the chair.

The following candidates were proposed for election as members of the Society :—

Allen, William Henry, York-street Works, Lambeth, S.W.

Barcroft, William, Redford, Moy, Co. Tyrone.

Birkett, Robert, Lion-lodge, Brondesbury, N.W.

Collins, John, 10, Friar-street, Doctors'-commons, E.C.

Cooper, Walter James, 39, Dulwich-road, S.E.

Davis, Edward Pindle, 24, Park-crescent, Portland-place, W.

Palmer, George, 58, Ebury-street, S.W.

The following candidates were balloted for and duly elected members of the Society :—

Cohn, Maurice, 24, Lancaster-road, Belsize-park, N.W., and 27, Throgmorton-street, E.C.

Few, Rev. Charles E., The Rectory, Seal, near Sevenoaks, Kent.

Jehangeer, Jehangeer Cowasjee, 14, Kensington-park-gardens, W.

The CHAIRMAN, in introducing Prof. Lankester, said the present time was especially appropriate for bringing forward a subject which bore so immediately on the great question of home food supplies; and he hoped the public would be disposed, therefore, to pay more attention to it than they had been accustomed to do. From returns made to the Fishmongers' Company, it appeared that the daily supply of fish to Billingsgate market was about 500 tons; these figures did not convey a very definite idea to the mind, but a ton of fish being equal to about 28 sheep, it followed that the daily London supply equalled 14,000 sheep, the annual supply 4,200,000 sheep, and, taking the supply to London to represent one-third that of the whole kingdom, it would appear that twelve and a half millions of sheep would about represent the total fish supply. This industry afforded employment in catching, curing, &c., to an army of 200,000 men, and a capital of about five millions sterling was employed in it. There was an old proverb to the effect that you should first catch your hare before cooking it ; but before catching it, it was first necessary that there should be a hare to catch; and it was especially with reference to this question in regard to fish that Professor Lankester was about to speak.

The paper read was—

THE VALUE OF A MARINE LABORATORY TO THE DEVELOPMENT AND REGULATION OF OUR SEA FISHERIES.

By E. RAY LANKESTER, M.A., LL.D., F.R.S.
Professor of Zoology in University College, London, and Fellow of Exeter College, Oxford.

It is a striking fact, to which attention has before now been drawn, that whilst the agriculturist, on whom we depend for a large part of our food supplies, has very largely availed himself of scientific knowledge in the treatment of crops and herds, the fisheries of our coasts, which provide an almost equally large amount of food to the people, have never been carried on with any regard to an accurate knowledge of the fishes on which they depend.

Agriculture is, in this country, a refined branch of chemistry ; but there has been no demand for a knowledge of marine life which might enable the fisherman to pursue his calling to the greatest advantage. In fact, our fishery industries are still barbaric ; we recklessly seize the produce of the sea, regardless of the consequences of the method, the time, or the extent of our depredations. In the same ignorant fashion as the nomadic herdsmen of Asia descend upon a fertile valley, and after exhausting it, leave it to time and natural causes for its recuperation, so do we treat the fishing-banks of our coast.

So long as fishing was relatively small in amount this method was not altogether objectionable. But with the increase of population, and the introduction of steam fishing boats and more effective instruments of capture, there is reason to believe that some at least of our coast fisheries are being destroyed, and that others may follow in the same direction.

Other civilised nations have perceived the necessity of attempting to regulate the various kinds of sea-fisheries on rational principles—that is to say, on principles based on an exact knowledge of the life and habits of the fishes which it is desired to capture. The French, the Norwegians, and above others, the Americans, have given attention to this matter.

There is reason to believe that the Romans had gained a special skill—now lost—in cultivating sea fish. Whatever that may have amounted to, it is certain that modern Europe has entirely neglected the cultivation and even the care of sea fisheries. It has been the merit of the Fish Commission of the United States to make the first attempt, in modern times, to deal with sea fisheries in the spirit of civilisation, that is of men who are determined

to understand and control, for the advantage of their race, the operations of nature, rather than to leave things to chance, the unknown development of physical causes.

The direct efforts of the American Commission, and the knowledge which scientific men have accumulated with regard to fishes, without designing to aid in the regulation and development of fisheries, do not enable us at present to answer many of the questions with regard to different sea fishes which we urgently require to know, if we are to deal like reasonable, practical men with our fisheries, so as to improve them, or even so as to prevent their extermination.

At the late Fisheries Exhibition Congresses, the universal cry, the one unanimous demand, was "more knowledge!" We cannot tell whether beam-trawling with steam-boats is injurious or not to some of our most valuable sea fishes until we have more knowledge. We have not sufficient knowledge to enable us to say that it would restore some herring grounds to their former richness, if the fishermen were kept off those grounds for a few years.

We do not know why soles are getting scarcer every year; we know nothing about soles, and so we can do nothing to remedy their constantly increasing diminution.

We do not know why oysters are scarce, or how to make them more abundant. A few hap-hazard attempts to cultivate oysters are now and then made, but have resulted in an immense loss of money rather than in gain, because we do not know all about oysters in the same precise and detailed way in which we know all about wheat, or all about pigs or chickens.

We do not know why some fishes swim in great shoals year after year, at certain seasons, near certain spots, and then, to the dismay of the fishermen, suddenly give up ever passing that way. We do not know whether we could hatch the young of soles, turbot, cod, and other valuable fishes, and stock the sea with them as we do our rivers with trout and salmon.

We do not know whether we could favour the increase of such fishes by cultivating in the sea their favourite food. In many cases we do not know what their food is.

We do not know whether we might increase these fishes by destroying their enemies.

In fact, we know exceedingly little about the minute details of the life of marine animals, and if we wish to deal with sea fisheries like rational men, we must find out these minute details, and gradually apply the knowledge so gained.

A laboratory on the sea-shore, provided with boats and fishermen, and having within its walls tanks for hatching eggs and watching sea fish, and conveniences for the work of naturalists trained in making such observations, is the way to meet the deficiency in our knowledge above noted.

This was perceived many years ago in France, and more recently, various laboratories have sprung into existence on the Mediterranean, and on the American coast.

There is not, as yet, any such place of investigation on the English coast, and it is this deficiency which the Marine Biological Association, of which my honoured friend, Professor Huxley, is president, and H.R.H. the Prince of Wales is patron, proposes to meet by building and maintaining a really efficient and thoroughly organised laboratory and experimental aquarium on the shore of Plymouth Sound.

The Association does not propose merely to build this place, but to arrange for the carrying out there of most important investigations on such questions as those I have a few minutes ago named. They have the hearty and earnest co-operation of all the naturalists in the United Kingdom, Scotch and Irish naturalists having united with their English brethren to form this institution.

Naturalists are glad to take part in the study of these practical questions, because the arrangements and the studies which are necessary to answer the questions of the practical fisherman are also just those which are necessary to advance the knowledge of the order of nature which forms the single object of truly scientific investigation. They will systematically and eagerly join with one another in the operations of the Plymouth laboratory, to obtain thorough knowledge with regard to the habits, food, breeding, and life conditions of all kinds of marine fishes, such as will be not only valuable but actually indispensable to the practical fisherman; and in the reports of the work done in the new marine laboratory which will be published by the Association, I do not doubt that the basis for future legislation and for future methods of sea fishery will be found.

I may here venture to mention some of the results obtained by the efforts of the naturalists who form the United States Fish Commission—at the head of which is Professor Spencer

Baird. I would, however, especially remark that the Commission has only been at work for ten years, and that very great practical results cannot be expected at once. A vast amount of knowledge has to be obtained before we can deal practically with all the various kinds of sea fishes; and it is to me a proof of the wonderful sagacity and activity of the American naturalists that they have already been able to do what they have done in the practical direction.

Professor Baird has especially attempted to artificially cultivate sea fishes. It seems to him that it is better, if it be possible, to replenish the seas by stocking them with young fish, to take the place of those removed by fishermen, rather than to impose legislative restrictions and penalties upon the fishermen. The attempt to artificially cultivate sea fish is an admirable example of the relation of scientific knowledge—that is, thorough and cause-reaching knowledge—to practical commercial operations.

There are two distinct stages in this attempt at artificial cultivation. The first is the scientific. You must ascertain how, when, and where, the fish naturally breeds; you must find out, experimentally, how to procure its eggs, fertilise them, and rear the young to a given size—on a small scale. That is the business of the scientific naturalist. When he has ascertained all the details of this operation—which differ entirely in the case of different fishes, and may take years to ascertain—then the second stage is entered on. The commercial man then comes forward, and in the light of the knowledge obtained for him by the scientific man, attempts the hatching of the fish on a large scale—not by the hundred, but by the million.

The American Fish Commission has undertaken both stages of the work, and the second is necessarily a very costly one. A very promising result has been obtained in the artificial breeding of codfish, and again in the case of the shad.

With regard to the codfish. When America was first discovered, cod was found on all its shores in great abundance, from which the headland of Cape Cod received its name; but as white men became more numerous on the shores, and cities began to grow, the fish began gradually to decrease in number, and to be driven off into deep water, because of the impure condition of the water; and now, in places where cod could be formerly caught from any point of rock, it is a rare thing indeed to catch this fish within several miles of the shore, and men who not many years ago could anchor a boat within a limited radius, and catch fish in large quantities, are now obliged to visit more remote ledges, several miles from the shore, and they are becoming scarcer even in deep water. It was in the hope of finding some remedy for this decrease that, in 1878 and 1879, the Fisheries Board began experimenting on the artificial hatching of these fish. Millions of eggs are laid by the cod where a few come to maturity, a large part being destroyed before they are hatched. Thus, if the eggs can be hatched, and the young placed in the water when they are old enough to partially take care of themselves until they arrive at maturity, the number would be vastly increased, and by constant work at hatching these fish, it was thought that much practical good might result. Many difficulties stood in the way, the most important being that the eggs floated, and clogged the arrangements which were made for keeping them in healthy condition, but after much experiment this difficulty was overcome. Arrangements were adopted by the American Commissioners which are the result of many trials. They now make use of a large vessel anchored out in the water, over the sides of which are placed pails, in which the eggs are placed, and kept in a state of constant agitation by steam drivers, which keep the water aërated by the movement given to them. It was found, however, that the place chosen for these experiments, viz., Gloucester, Mass., was by no means adapted for the work, because of the impure water and the extreme cold. The object of the present work was merely experimental, and it mattered little whether the fish hatched lived after being placed in the water in the first instance. Several millions of young fish were thus successfully hatched and placed in Gloucester harbour, but because of the impurity, it was scarcely expected the fish would be heard of again. But in the spring of 1882, reports began to be circulated that young codfish, of the deep sea species, *Gadus morrhua*, were abundant in Gloucester harbour, and subsequent investigation proved this report to be true. Since the cod first left the coast of the United States, they have not been seen in the Massachusetts harbours in any abundance, but at this time, even in the impure docks of Gloucester harbour, it is not unfrequent for boys fishing for perch and flounders to catch young cod. Several generations are distinguishable, and as there is but

one other place where a similar abundance is reported, there is every reason to believe that the fish so caught are the Fish Commission cod, and that the other school are but an offshoot from the original lot which was hatched and turned out into that harbour. It is, of course, expected that in time this fish will migrate to the purer and cooler water outside the harbour. There are fishermen now in Massachusetts who are making good catches of these cod in the harbour itself. These experiments, although primarily successful, have had an additional success which was not expected. Gloucester not being naturally suited for hatching cod, the Commission has begun to build extensive hatching houses at Wood's Hole, another place on the coast more favourably placed, where, in a few years, artificial deep-sea fish hatching will be carried on extensively.

The practical results with regard to shad are also very remarkable. The shad, I may mention, is a fish very little known in England. There is a species of shad which frequents the English rivers, but the American shad is a kind of herring which runs up the estuaries, and is caught in large numbers in the large rivers on the east coast of America. These fish spawn in the rivers, but in certain seasons it has been observed that when the weather is cold they fail to come up to spawn. They place their spawn lower down, and the consequence is that the ordinary fishing grounds are deserted by the fish. Accordingly, the American Fish Commission met this difficulty. To avoid what has been called a shad famine, they caught the fish on the way to the spawning ground, fish which they knew would not go up the river on account of its being a cold season, and artificially procured the eggs, fertilised them, and carried the young up the rivers, and there turned them out, and so stocked the river with shad when the fish naturally would have avoided the river. That is the process which is now being carried out every year, and they are able to very largely stock the rivers on the coast of America with this important food fish. This shad is very much valued in America. A few years ago a fine shad of some four or five pounds weight would fetch as much as 2s. 6d. in the market, but now it is to be had for about half that price, in consequence of the operations of the Fish Commission in increasing the supply of this fish by artificially taking the ova, fertilising them, and turning the young into the rivers.

Again, in dealing with the American oyster, the Commission has obtained what promises to be a very great success.

Oysters are even more esteemed in America than they are in this country, if that is possible. The catch of American oysters is very much larger than on the English coast, and there is an enormous consumption of them in all the large American towns. The Commission were very anxious to see if something could not be done in the way of securing even a more ready supply of oysters than they have at present. They have not been threatened in America with an oyster famine as we have, but still it was felt that something might be done to gain greater control over the oyster fisheries. The American oyster is a different species to the European; it is the *Ostrea virginica*, whereas ours is *Ostrea edulis*. In 1878-79, Professor Brooks, of the John Hopkins University, Baltimore, was requested by the Fish Commission of Maryland to study the oyster, with a view to seeing if anything could be done in the way of dealing with it in a more satisfactory way. He discovered a very curious fact. The European oyster is known to unite in one individual the two sexes; and, further, the European oyster hatches its young within the folds of the soft parts of the body underneath the shell. The young pass the early days of existence in the shell of the mother, and then swim out into the water in immense numbers. Prof. Brooks found that of the American oyster neither of these things is true. The male and female are distinct, and the eggs are cast into the water by the female, and are there fertilised by the soft row or sperm shed by the male, and the growth takes place freely in the sea water. He followed the stages of this growth, and showed that it is quite easy to collect a number of female oysters and a number of male oysters, fertilise the eggs in sea water, and obtain the young in glass vessels, and carry them where he pleased. It was subsequently found that by turning them out into ponds, properly constructed, the young would swim in the water for some time, and then fix themselves on tiles and other objects placed in the ponds, and there grow into actual young oysters with shells. In their early condition they swim freely in the water, and have no shell. This information, gained by Professor Brooks by work extending over a period of two years, is now being applied by the American Fish Commission. They are constructing large ponds in which the young swimming oysters can be reared by artificially impregnating the eggs. The great difficulty in the matter was, at first, that if you turned

them into the sea over any oyster ground, they would get washed away by the currents; and, on the other hand, if you turned them into an ordinary pond, the water was not changed sufficiently to keep the young animals in health. Accordingly, they have made, at certain points of the coast, ponds with porous banks, constructed with sandstone and shingle, through which the sea water percolates at the rise of the tide, and passes out again as the tide falls; but the young oysters are stopped. Several ponds are now being constructed in this way, and the young oysters are being successfully reared. Thus, the American Commissioners get the spat to fall, and attach itself to tiles and other objects purposely placed in the pond, and when once attached to these bodies, the oyster can be dealt with. He can be placed in any part of the sea you please, and left to grow. In this way the American Fish Commission is now getting the oyster perfectly in hand, and no doubt they will be able to deal with oysters very much as agriculturists deal with gooseberries or turnips.

But there is an almost unlimited field of work before the American Commission.

Experiments and observations similar to those carried out by the American Commission, will be undertaken by the Biological Association at Plymouth. For example, the artificial cultivation of that most valuable of British fishes, the sole, will be at once taken in hand. At present absolutely nothing is known as to the spawning of the sole—the male fish is not even recognised. In the first instance, the naturalists at Plymouth will study the eggs and the mode of spawning of the sole, and the way in which the eggs are fertilised naturally. Then the necessary conditions for the rearing of the young fish will be ascertained. After that it will be possible to hatch a vast number of young soles and turn them out into Plymouth Sound, and to determine in this particular area, which is admirably adapted by its natural delimitations for the experiment, whether the take of soles in the Sound has been increased by the operation.

Similar experiments will be tried with other fish; and also knowledge will be gained as to the food of various fishes, and the causes which determine their movements, their increase, and their diminution in the neighbourhood of Plymouth.

This knowledge will help us to form sound and reliable conclusions as to the supposed injurious effects of steam trawlers and other modes of fishing, and so lead on to sensible and valuable legislation in regard to the seasons and modes of fishing best suited to obtain the maximum benefit from the harvest of the sea.

The English oyster, though differing from its American congener, can no doubt be brought under control by a thorough-going knowledge of all the conditions affecting it at all periods of life; and this it will be a first duty of the Marine Biological Association to attain.

It is a very curious thing that large sums of money have been spent in the attempt to cultivate oysters, and at the same time the people who have, I may say with all respect, recklessly expended their money in this way have not cared to ascertain minutely all that can be learned with regard to the history of the oyster. In the case of the European oyster you get every year a considerable number of young produced in the natural way; you cannot undertake artificial impregnation of the eggs because the young have to grow within the shell of the parent, but there does not seem to be much difficulty about that. In the breeding season you can get immense numbers of young from the parent oysters, thrown out of the shell, swimming about in the water; the great difficulty is to get these young to fall. Large quantities of these swimming spat are produced, but it is not every year that there is a "fall of spat," and the conditions which one year cause the spat to fall and fix themselves to stones, and give you a crop of young oysters, or, on the other hand, the conditions which prevent that, are not known. There are various very probable causes. It is extremely probable that temperature has a great deal to do with it, but still it is not very definitely ascertained. If temperature has to do with it, there appears to be no reason why the waters in which the young are cultivated, or thrown out, should not be artificially raised in temperature so as to cause them to carry on their life to a later stage, when they would fall and attach themselves to the stones and rocks at the bottom of the water. That can be done in ponds. At the present time no such attempts have been made in England, but in Holland a certain company of Dutch naturalists have been making experiments on this matter. They have not yet obtained very definite results, but they seem to have come to the conclusion that an artificial raising of the temperature of the water in which the young oysters is hatched would favour their attachment and further their growth. They have constructed ponds in which that kind of ar-

rangement is carried out, and the experiment is still in progress. They have also shown that a great cause of the failure of the oyster in certain localities is that the currents carry the young away. The mouth of the Scheldt is an exceedingly favourable place for oyster cultivation, because the outgoing current is always counterbalanced by a reverse current at the turn of the tide, and the young which are naturally spawned by the oysters in the mouth of the Scheldt are not carried right away. They get carried out a bit at one period of the tide, but are brought back again after a few hours, until the period of growth is reached, when they sink to the bottom, and attach themselves to the stones. So the oyster plantations at the mouth of the Scheldt prosper, and the young are not lost. But in many places where the cultivation of oysters has been attempted, the young have been entirely lost by the fact that the ground is not well chosen. It is such inquiries as these which can be carried out by the aid of a laboratory and the presence of skilled naturalists. At Plymouth there is an exhausted or deserted oyster fishery in the River Tamar which opens into the Sound. It would be possible for the Marine Biological Association to use this as an experimental ground, and to see if it cannot be revived.

Lastly, the subject of "bait" is one of great importance, which we shall be able to deal with effectively. Not only shall we find new and effective baits, at present neglected by our line fishermen, but we shall be able to direct the cultivation of such valuable baits as the mussel and the limpet.

There is no fact which gives one so vivid an idea of the immense commercial value of sea fisheries as the amount which is annually expended on mussels for use as bait in those fisheries. There are few statistics on this subject, or indeed on any matters relating to our sea fisheries, and it will be one object of the Marine Biological Association to collect such statistics. But there is a certain amount of information as to the use of mussels for bait. Thus, between October, 1882, and May, 1883, twenty-eight boats engaged in the haddock fishery at Eyemouth, in the North of Scotland, used 620 tons of mussels (about 47 million individuals), costing nearly £1,800 to the fishermen, that is to say, over a million and a half of mussels for the whole time, or about 7,000 a day to each boat—at the rate of one penny for twelve mussels. The total value of mussels used for bait in the deep sea line fisheries of the British coasts must amount to many hundred thousand pounds in a year—and we can only roughly guess at the value of the fish caught by this large expenditure on bait. In spite of the great economic importance of the mussel, its complete history of reproduction and growth is not known, and though in France and Germany it is carefully and profitably cultivated, very few attempts have been made on the British coast to protect or to artificially favour mussel scalps so as to make them remunerative properties.

This is a subject with which a marine laboratory would enable us to deal in a very short time. The same general remarks, *mutatis mutandis*, apply to the second most important bait, viz., the limpet.

Before concluding this sketch of the work which lies before the managers of a marine biological laboratory, I may say a few words as to the nature of the buildings and equipment required for such an institution.

The most efficient scientific laboratory of the kind is that erected at Naples by Dr. Dohrn, a drawing of which is exhibited. The Naples laboratory, with its tanks, row boats, and steam launches, has cost about £20,000, and involves an annual expenditure of about £4,000. A staff of observers is paid out of this sum, and the efforts of the institution have hitherto been entirely directed to the obtaining of accurate scientific knowledge with regard to the fauna and flora of the Bay of Naples. It is justly regarded as one of the most important scientific institutions in Europe.

The United States Fish Commission have erected, from time to time, various small laboratories, and are now about to expend £10,000 on a laboratory at Wood's Hole, and £20,000 on building fish-ponds protected by piers of masonry. Since its commencement, the United States Commission has received from the Imperial revenue about £300,000. In 1884 alone it received £70,000. It must be remembered that these large sums cover the expense of very extensive operations in fish-breeding on a commercial scale, and are not solely for the purpose of preliminary investigation.

The Marine Biological Association proposes to proceed in a modest manner, arranging in the first instance for the carrying out of the necessary experimental inquiries. A site has been obtained on the Citadel-hill, at Plymouth, by permission of the authorities of the War-office, and here will be erected a laboratory, comprising on the ground floor large and small tanks, and above, a series

of working-rooms fitted with small tanks. Through all a stream of sea-water will be driven by pumping apparatus, from large tanks in the basement, containing several thousand gallons. These reservoirs will only be replenished two or three times in the year. Boats, including a steam-launch, will be required, and two or three fishermen, who will act as attendants. A resident superintendent, who will be a thoroughly qualified naturalist, will be appointed at a salary of £200 a year, and will be lodged on the premises. Naturalists will frequent the laboratory at their own expense for the purpose of study, and from time to time competent investigators will be appointed to carry out particular inquiries. The latter will be paid for their work from special scurces, not from the general income of the Association until that reaches a large amount. Great assistance will be afforded to the work of the Association by the local fleet of fishing boats, which is very numerous, and comprises some vessels of large size. It is estimated that a capital sum of £10,000, and the prospect of an income from annual subscribers, members of the Association and others, of about £500 a year, will enable the important work which has been taken in hand to be commenced. The Council of the Association feel very great confidence that they will be able to obtain annually sufficient funds to keep the laboratory in efficient working order when once the capital sum of £10,000 has been subscribed. Towards the latter amount they have already raised a sum exceeding £5,000. From Plymouth as a centre, in the course of future years, the operations of the Association will extend, and additional laboratories will no doubt be constructed hereafter by the Association on other parts of the coast of the United Kingdom, should the first one prove a success, and the work carried out through its agency meet with public approval and support.

Whilst the Marine Biological Association aims at obtaining, by the operations of its laboratory and experimental aquarium, that knowledge which is clearly necessary for the improvement and regulation of our sea fisheries, it must be remembered that its work will necessarily enlarge and advance the great science of biology, and that to many of us this is its surest promise of utility, for we cannot always directly govern the march of scientific progress. The whole field of knowledge must be cultivated, in the simple faith that the increase of knowledge is the greatest good which human effort can achieve. By adopting a thorough and comprehensive scheme of study of the problems connected with the life of fishes, we shall, as invariably happens in the history of science, obtain results which at present we cannot foresee, but which, we may feel assured, will yield in unexpected ways rewards and blessings to humanity.

DISCUSSION.

The SECRETARY read the following letters from the Duke of Argyll and the Right Hon. Joseph Chamberlain :—

May 10th, 1885.

MY DEAR PROFESSOR LANKESTER,—I am very sorry that an old engagement on Wednesday will render it impossible for me to be present at the Society of Arts, but if it falls in your way to do so, you may express my very strong sense of the great practical value of the study of marine biology in all matters of legislation, or of regulation in respect to the fisheries.

It is not too much to say that the discoveries so made will be the most important of all guides to practical work.—Yours truly, ARGYLL.

40, Prince's-gardens, S.W.,
May 11th, 1885.

MY DEAR SIR,—I am greatly interested in the success of your Association, and believe that much good will result from the careful experiments which you propose to institute.

I am sorry that I cannot attend your meeting on Wednesday; but I have a previous engagement of long standing which I cannot postpone.—Yours truly. J. CHAMBERLAIN.

Professor E. Ray Lankester.

Mr. J. W. B. WILLIS BUND said he was much interested in the experiments the Association were about to try, but his interest was mainly in the inland and coast fisheries, which he hoped would be greatly benefited. He had now for some years had the practical management of the largest fishery district in this country, the Severn, and he felt that there were great defects in the existing law—defects which he believed arose from ignorance of natural history on the part of our legislators. At a particular time fish were either scarce or plentiful, and it was assumed that those conditions were going to happen each year, and legislation took place accordingly. Consequently, the very laws which were intended to protect the fish, in many instances, were really a most serious obstacle to their protection. For instance, there was a provision in the Salmon Fishery Acts that on Sundays the sluices and drains should always be kept

shut, the result being that in many cases the fish could not get a free passage down to the sea. He believed, though he had not yet sufficient evidence to assert it positively, that a great deal of the salmon disease was caused by this very ignorance of natural history. There were inspectors of fisheries, whose duty was supposed to be to find out these things, but his experience was that they simply sent round a series of questions as to the number of fish caught, the revenue, and the prosecution of poachers, and cared nothing whatever about the natural history of the subject, and rather discouraged Fishery Boards spending any money in that way. They really knew nothing about the habits of the migratory fish; a few broad facts were known with regard to salmon, but that was all. He had been endeavouring to establish a series of observations with regard to temperature, to see if it had any effect on the migration of fish, and though it was too early to say what the results would be, he believed it would be proved that cold springs had a bad effect on the migration of the fish. About the causes and reasons of the migration of the eel they knew nothing. This was a poor man's fish, and might be cultivated largely, but Fishery Boards, from ignorance or want of encouragement, did not cultivate eels at all. There was a kind of shad in some English rivers (not the same, however, as the American, which used to afford good sport to anglers, but of late this fish had been gradually disappearing from the rivers he was best acquainted with; why, it was difficult to say. Whether it could be restored, as it had been in America, he did not know, but at any rate experiments might be tried. Another important question was the food of fish. When fish were found dying out in certain rivers, one of the reasons was that their food also was dying out, and it might be quite as important in preserving fish to cultivate the food as to cultivate the fish themselves. What did salmon eat when they went out to sea? Every one had a theory of his own, but he did not believe any one could support it by satisfactory evidence. Then, again, the question of bait was extremely important from this point of view. There was, at present, a great destruction of bait, probably from ignorance. At different times of the year different bait might be used, but fishermen said a certain bait was the best, and used it at all times, even to the exhaustion of the supply. This was particularly the case with lamperns, which had been nearly exhausted in the Thames, and in the Severn they were much reduced, being caught in large numbers and sent to the north for bait for cod fishing. If some other bait could be found, this might be prevented, and a useful food fish preserved. One result of the labours of the Association he trusted would be the laying of a sound basis for the regulation of fisheries. This was rather an unpopular notion, the general idea being that fish were so prolific, and the supply so large, that anything like regulation was absurd. He did not share that view, and believed regulation was necessary. It did not follow because they did not know what the regulations ought to be, that, therefore, all regulations was unnecessary. At the same time he did not expect any great results would be achieved immediately, and it would be worse than useless to rush hastily into legislation on the results of the first experiments. They must be continued for some years, and then data would be accumulated on which legislation might be based, which would lead to a permanent improvement in our sea fisheries, and to the development of one of the most important of our industries, which yielded a large supply of food, and, at the same time, was of the greatest importance, as being the nursery of the navy.

Mr. W. Botly said he had been particularly interested in the first portion of the paper, which referred to the importance of the fish supply in comparison with that from agricultural sources. When America, and other countries, were establishing marine laboratories, it was necessary that an island like England which could not raise sufficient food for its inhabitants, should not be behindhand in cultivating a scientific knowledge of fish culture. He hoped the Association would receive the encouragement which was due to it from a national point of view.

Mr. W. G. Trewby agreed that the establishment of a marine laboratory was very essential, but thought great care should be taken, before expenditure was incurred, that the most suitable spot was selected; and he doubted whether a point close to the mouth of a river was a proper place for experiments of this kind. Prof. Lankester had spoken of the purity of the water, but it could only be comparatively pure so near the mouths of two rivers which must bring down a quantity of *débris*. Two experiments had been made in the culture of oysters, but he doubted whether they had not been injured from the same cause. The largest supply of oysters to this country formerly came from beds between Jersey and France, where the water was remarkably pure.

Mr. T. Christy said he had seen lately that in America sufficient cod were hatched by the Fishery Commission to replace all the cod caught by all nations which frequented the fishing grounds there. That one fact was worth a deal of theory, and showed the practical results of this kind of work. This Association would have the assistance of all the work done by other societies, and would, therefore, have a much better chance of making a fair start than some people seemed to think. As Professor Lankester had explained, it was very important to know how to hatch the fish, but still more to know on what they lived. He was quite sure that if the public would support this Association, they would be amply repaid by the information which would be gained.

Sir Lyon Playfair, K.C.B., M.P., F.R.S., said he had presided over two Commissions on the Fisheries of the United Kingdom, and had been much struck by the manner in which such inquiries were conducted here, as compared with other countries. In this country the Commissioners went to the various fishing stations, and inquired of the fishermen about the habits of the fish, and the conditions which prevailed as to the mode of catching them, but he had found, by experience, that the last person in the world to know anything about fish was a fisherman, and you could not possibly obtain any sound knowledge on which to legislate in that way. Fishermen had a limited area from which their experience was acquired, and were much prejudiced in favour of their own customs and against any other methods. Although on one of these Commissions they had a most distinguished scientific man, Professor Huxley, it was perfectly impossible to obtain any real information on which the public could rely; and it was also found that, as the result of such information as was obtained, the most absurd laws were passed. For example, a close time for herrings was established, varying at different parts of the narrow waters, such as the Clyde and its estuaries; and it was hoped that by giving a close time to the herring they would breed much more largely. But this legislation proved to be not for the protection but for the destruction of the herring. At that time of the year cod and ling could only be caught by herring bait, and as the fishermen were not allowed to catch herring, the cod and ling multiplied exceedingly; herrings were devoured by their natural enemies, though the fishermen got none. Sometimes fourteen herrings were found in a cod's stomach; but allowing only four or five a day for each cod caught during the close time, the cod and ling caught as many herrings as all the fishermen in the United Kingdom, and 600 besides. What did America do? She appointed Commissioners of Fisheries, who did not go and ask the fishermen as to the habits of the fish, but interrogated nature. They studied the habits of the fish, their food, their migration, and their enemies. They took any evidence the fishermen chose to give, but attached very little importance to it; they asked nature at first hand in what manner the fish bred, in what temperature they spawned, and in that way they gained an enormous amount of knowledge which had increased the production of fish all over the United States immensely. Having spent the autumn for the last eight years in America, he had visited all the fishing-stations, and acquired all the knowledge he could as to their mode of conducting these inquiries. There had been one Commission here, under Lord Dalhousie, which produced one very admirable report, by Professor Macintosh, of St. Andrew's, the consequence of which was that that gentleman was burned in effigy, on account of the fishermen's dislike to the scientific truths which he made known. If anything useful were to be done, the stupid fashion of examining fishermen must be abandoned, and they must go straight to nature, who always told the truth, if she were approached in a reverential spirit. It was astonishing how little fishermen knew about fish. In Lord Dalhousie's Commission it appeared that they thought all fish spawned like the herring, that the spawn sank to the bottom of the ocean, and attached itself to rocks and weeds; whereas, in the case of a large proportion of flat fish—it did not sink at all, but floated on the surface and was hatched there. It was to make inquiries of this nature that Professor Lankester was so anxious to establish a marine station, merely to keep up to the level of other nations. France, Germany, Norway, Sweden, and America were establishing these stations, and making these inquiries which were so necessary in order to understand the habits of fish. The Americans had already done one thing which, at first sight, seemed impossible. The cod was only a winter fish on the coast of America; in summer it went away to the bank of Newfoundland where the Arctic stream cooled the water, and in this cool water the cod produced their young. Now, the American Commission asked the question was it possible to so alter the habit of the cod that it would spawn on the coast of America, instead of going away to British territory. They knew that all fish loved the place where they were born; they said in America that a trout would go back to the very stone under which it was bred, although it had been out to sea. The Americans were now hatching cod in millions, and as these cod loved to go back to the place where they were born, they were not now going to Newfoundland, but having been born on the coast, they remained there during the summer in spite of the heat; the fishermen were now catching them in considerable quantities, and called them the "Commission cod." The shad, which was very valuable in America, would only spawn within a range of 10 degrees. Therefore, when they found the temperature of the water sinking, and the shad going out to sea, the Commission steamers, which were admirably fitted out in every way, were sent after them, caught them full, expressed the spawn, brought it back and hatched them; and, whereas formerly there was a shad famine about every fourth year, in consequence of low temperature, this took place no longer, because the Commission hatched them under the most favourable circumstances. Was England to remain the only country which did not carry out these inquiries scientifically? A small station had been established at Granton, near Edinburgh, but it was not sufficient for the purpose; they required several in different parts, and especially one central station, such as was proposed to be established at Plymouth. It was really disgraceful that a country washed all round by the sea—a maritime nation *par excellence*—should be the only one not conducting these scientific inquiries.

The Chairman, in proposing a vote of thanks to Professor Lankester, said it appeared that even

scientific men were as little acquainted with the domestic habits of fish as other people. This was a very undesirable state of things. Whilst the sole was a most useful, wholesome, and palatable fish, it was decreasing in quantity and increasing in price. It formed only $\frac{1}{50}$th part of the whole of the fish which came to market, being less proportion than either salmon or eels; whilst herring furnished $\frac{1}{18}$th, mackerel $\frac{1}{9}$th, mussels and winkles together $\frac{1}{7}$th, and haddock and plaice nearly a half. It would be gratifying to those who took an interest in the Fisheries Exhibition, to know that, apart from the founding of two institutions, one for the benefit of widows and orphans and the other for the easier and cheaper distribution of fish to the consumer, the Exhibition had already borne good fruit, inasmuch as it had proved that by good cooking the very commonest kind of fish might be made very palatable; and large quantities that were formerly thrown into the sea, or used for manure, were now brought to London and sold for food. Scientific inquiry had, to some extent, been made into the habits of the salmon, and as one result that fish had already increased in quantity, and decreased in price, very much in the same ratio in which the reverse had been the case with soles. The migration of fish had been referred to, and he might show its importance by reference to the fact that on the west coast, in good years, the export trade in pilchards sometimes amounted to 46,000 hogsheads, while the next year, owing to the migration of the fish, not more than 6,000 hogsheads would be exported. This was a very undesirable state of things, because such uncertainty prevented the application of capital to the industry. He hoped the laboratory or museum would soon be founded; he should certainly lay the matter before the Court of the Fishmongers' Company, and no doubt they will do their utmost to assist the movement.

The vote of thanks having been carried unanimously,

Professor LANKESTER, in reply, after thanking Sir Lyon Playfair, who was a thorough master of the subject, for coming at some inconvenience to support the cause, referred to the question of bait. Fishermen were very capricious about bait, and went very much by rule of thumb and tradition. Mussels, which were considered the most killing bait in the deep sea-line fisheries on the British coast, were not used by American fishermen, though there were enormous numbers on the American coast. They used the soft clam, which though fairly abundant on the English and Norwegian coasts, was never used by English or Norwegian fishermen. Mr. Trewby seemed to think that the water in Plymouth sound was not so pure as could be desired, but he need hardly say that that locality would not have been selected unless they had been fully assured on the matter. Those two rivers did not bring down any large quantity of fresh water, and did not affect the character of the fauna, for thoroughly vigorous sea fauna were found right up to the shores. In conclusion, he would say that he should be very happy to afford any further information about the Association, of which he was the secretary, to anyone who would apply to him on the subject.

The Court of Assistants of the Fishmongers' Company, at their monthly court held on Thursday, May 14th, unanimously resolved, on the motion of the Prime-Warden, Mr. E. L. Beckwith, seconded by Mr. J. H. Fordham, that a grant of £2,000 be made to the Marine Biological Association of the United Kingdom. £1,000 to be paid this year, and the remainder in annual sums of £200 during the next five years.

Correspondence.

VENTILATION OF SEWERS.

I would thank Dr. Carpenter for the courteous manner in which he, on page 719, replies to my letter on page 640, and I am glad to find that we are in accord upon a number of points. I am unable, however, to agree with him on the points wherein we differ, as I do not consider his reasons conclusive for the views he enunciates.

Dr. Carpenter wishes interceptor traps done away with, and the house drains and soil-pipes made to serve as ventilating tubes for the public sewers. I wish these traps to be used, and all ventilation of the sewer to be outside of the interceptor trap, and outside of the house. I published that idea about twelve years ago, and all my experience goes to prove it to be correct, and it is the view held by the great majority of sanitarians—physicians and engineers included—in the kingdom.

I do not say that "no man shall assist the local authorities in its duty to provide for sewer ventilation," but I do say that the man who would do so in such a manner as to hurt the wholesomeness of his house and endanger his own health, would be a fool. Dr. Carpenter argues that because he has a good antidote at hand, therefore, all and sundry may freely risk taking poison. I consider that prevention is better than cure, and, so far as sewer air is concerned, it is much safer to keep it out of our houses altogether, than to depend upon the diluting effects of the atmosphere to prevent harm from it.

What Dr. Carpenter says about public sewers being so constructed as to have "no sewer gas" in them, is, I consider, purely fanciful. We have to deal with things as they are and as they are likely to be, and there is and will be dangerous air—including disease germs—in the sewers, until there is some plan of dealing with them not yet known to us.

I consider it is quite a mistake to say that the

dangers I desire to obviate are really increased by my interceptors, especially if said interceptors are only six-inch, or less. Six-inch interceptor traps are easily flushed, and are as natural, useful, and necessary as the doors of a house.

Is it really true that "fresh sewage is not dangerous to anybody"? Would not fresh excreta from a typhoid-stricken individual be highly dangerous if not disinfected?

I consider Dr. Carpenter is wrong in saying that, "without concentration, sewer gas is perfectly harmless." He gives, in this connection, ventilation more credit than it deserves. It is not merely chemical matters we have to deal with in sewer air, but often living devils, with an enormous power of self-multiplication; and allowing, as Dr. Carpenter says, that disease germs emitted from a sewer into the open air die in a few seconds, it is possible that, when these are discharged into the atmosphere of the interior of a house, they may live often many minutes.

It has been frequently asserted that people have caught disease in the streets from the sewer air coming out at the gratings—gratings at side of pavement are the most dangerous—so how much more liable would they be to do so inside a house if breathing sewer air there, and especially during sleep? Even with first-class sewers there is often special danger from them in seasons of drought, and stinks from public works, slaughter-houses, hospitals, sewage, &c., are better to be kept out of our house pipes.

The present law and practice are, as I think happily, against Dr. Carpenter's views, and I consider he will require to give much better reasons than he has done to justify alteration of these, and before I could side with him.

In conclusion, I beg to point out that Dr. Carpenter has said nothing to meet my objection on page 641:—"Besides, to use our water-closet soil-pipes to ventilate the sewer would be to open up a highway into our houses for the sewer rats."

W. P. Buchan.

Glasgow, May 9th, 1885.

INSTITUTE FOR LIVING LANGUAGES.

In his letter on the above subject, with the object of which I heartily agree, Mr. Hyde Clarke says, "Beyond French and German classes, and what is done in the City of London College, the teaching in the metropolis is scanty," &c. Allow me, however, to point out that the evening classes in King's College, which have been established upwards of twenty-five years, have at all times furnished ample provision for the study of the above-mentioned languages, as well as for Spanish and Italian, not only for mere scholarly objects, but also for purely practical or commercial purposes, and many a clerk who has obtained a lucrative situation in a merchant's office at home or abroad, was solely indebted for his success to the practical knowledge of modern languages which he acquired in the evening class department of this College. Nevertheless, the classes, although in themselves very successful, have not attracted a number of students in proportion to the multitude of clerks to whom a knowledge of modern languages is of vital importance. Nor has this been the case, I think, in other institutions.

The German clerk who comes over to this country has, as a rule, gone through a regular "commercial course;" he is well versed not only in English but also in French, and frequently likewise in Italian and Spanish. Why does not the English clerk follow his example?

Mr. Hyde Clarke says, "In the time of Queen Elizabeth, young ladies were better linguists than most men are now." Allow me to state that this is still the fact. If our young men knew the living languages as well as their sisters do, it would be very hard for a Continental clerk to obtain a situation in consequence of his linguistic superiority.

C. A. Buchheim, Ph.D.

King's College, London,
May 12th, 1885.

NOBERT'S RULING MACHINE.

In my description of the division-plate (see *ante* p. 710) it should be stated that the fine divisions (to five minutes in arc) on the two bands of silver imbedded near the circumference were probably made by means of a large circle-divider, and the 21 (not 20) rows of "dots" from the divisions on the silver bands. The "dots" were probably utilised for cutting toothed wheels before the machine was converted into a ruling machine, and they may possibly have been utilised for dividing micrometer-plates.

John Mayall, Jun.

224, Regent-street, W.
9th May, 1885.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at Eight o'clock:—

May 20.—"The American Oil and Gas-fields." By Professor James Dewar, F.R.S. The Right Hon. Sir Lyon Playfair, K.C.B., F.R.S., M.P., will preside.

Indian Section.

Friday evenings at Eight o'clock.

May 15.—"The Golden Road to South-Western China." By R. K. Douglas, Professor of Chinese at King's College, London. The Hon. Edward Stanhope, M.P., will preside.

Foreign and Colonial Section.

Tuesday evenings at Eight o'clock.

May 19.—"New Britain and the Adjacen Islands." By Wilfred Powell.

Cantor Lectures.

Monday Evenings at Eight o'clock.

The Seventh and concluding Course, "The Manufacture of Toilet Soaps." By C. R. Alder Wright, D.Sc., F.R.S., F.C.S.

Lecture III. May 18.—Manufacture of Spirit-made Transparent Soaps—Machinery and Appliances employed in the preparation of Bars and Tablets—Cutting and Shaping—Squirting, cold and hot—Stamping and Drying—Valuation of Toilet Soaps by Chemical Analysis—Constituents often admixed, objectionable and otherwise—Discussions of Analytical Methods for the Determination of "Free Alkali," and Recent Researches thereon—Hydrolysis of Soaps in contact with Water—Classification of Toilet Soaps in accordance with the results of Chemical Analysis—Analysis of various British and Continental Soaps, and Discussion of their General Characters—Qualities requisite in Soaps intended for Delicate Complexions and Tender Skins.

MEETINGS FOR THE ENSUING WEEK.

Monday, May 18...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. C. R. Alder Wright, "The Manufacture of Toilet Soaps." (Lecture III.)

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. Mr. A. Reckenzaun, "Electric Tramcars."

Surveyors, 12, Great George-street, S.W., 8 p.m. Adjourned Discussion on Mr. W. Matthews's paper, "The Influence of Taxation upon Rent."

British Architects, 9, Conduit-street, W., 8 p.m. Mr. Alexander Graham, "Remains of the Roman Occupation in North-Africa, with special reference to Algeria."

Asiatic, 22, Albemarle-street, W., 4 p.m. Annual Meeting.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Paper on "The Results of Archæological Research in North America."

Tuesday, May 19..SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Mr. Wilfred Powell, "New Britain and the Adjacent Islands."

Royal Institution, Albemarle-street, W., 3 p.m. Professor Gamgee, "Digestion and Nutrition." (Lecture X.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on Mr. A. M. Thompson's paper, "The Signalling of the London and North-Western Railway." 2. Prof. Osborne Reynolds, "The Theory of the Indicator and the Errors in Indicator Diagrams." 3. Mr. A. W. Brightmore, "Experiments on the Steam-Engine Indicator."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m. Mr. A. K. Connell, "Indian Railways and Wheat Trade."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Prof. Julius von Haast, "*Dinornis oweni.*" 2. Dr. Mivart, "Notes on the Pinnipedia." 3. Dr. F. H. H. Guillemard, "Report on the Collections of Birds made during the Voyage of the yacht *Marchesa.*" Part IV. "The Collection of Birds from the Island of Sumbawa." 4. Dr. A. A. W. Hubrecht, "*Echinoptilum macintoshii*, a new Pennatulid from the Japanese Seas."

Wednesday, May 20...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Professor James Dewar, "The American Oil and Gas-fields."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Dr. W. Köppen, "The Temperature Zones of the Earth in Connection with its Biological Conditions." 2. Lieut.-Col. H. S. Knight, "Velocities of Winds and their Measurement." 3. Dr. W. Köppen, "Note on Mr. C. Harding's Paper on Wind Velocities." 4. Rev. James Davis, "Note on a peculiar Form of Auroral Cloud seen in Northamptonshire, March 1st, 1885.

Hospitals Association, 1, Adam street, Adelphi, W.C., 8 p.m. Miss Louisa Twining, "Thoughts on the Diet of Nurses in Hospitals and Infirmaries."

Pharmaceutical, 17, Bloomsbury-square, W.C., 11 a.m. Annual Meeting

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Rev. Dr. Sparrow Simpson, "Master John Schorn." 2. Mr. Thomas Blashill, "The Cistercian Abbey of Dore." 3. Dr. Alfred C. Fryer, "Notes on Cornish Crosses."

Royal Botanic, Inner Circle, Regent's-park, N.W., 2 p.m. Summer Exhibition of Plants, Flowers, and Fruits."

Thursday, May 21...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Chemical, Burlington-house, W., 8 p.m. 1. Dr. W. J. Russell, "Spectroscopic Observations on dissolved Cobaltous Chloride." 2. Mr. Andrew Thomson, "Colorimetric Method for the Estimation of Iron." 3. Mr. V. H. Veley, "Some Sulphur Compounds of Calcium."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. G. A. Storey, "Footprints of the Beautiful."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. C. Meymott Tidy, "Poisons." (Lecture I.)

Historical, 11, Chandos-street, W., 8 p.m. Mr. C. A. Fyffe, "The Establishment of Greek Independence, with especial reference to the policy of England and Russia at that epoch."

Numismatic 4, St. Martin's-place, W.C., 7 p.m.

Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Mrs. Shiel, "Physiology and the Laws of Health." (Lecture XII.) "Hearing."

Friday, May 22...United Service Institution, Whitehall-yard, S.W., 3 p.m.

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Mr. W. H. Pollock, "Garrick."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

Browning, University College, W.C , 8 p.m. Paper by Mr. J. T. Nettleship.

Saturday, May 23.. Royal Institution, Albemarle-street, Prof. W. Odling, "Organic Septics and Antiseptics." (Lecture II.)

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p m.

Physical Science Schools, South Kensington, S.W., 3 p.m. 1. Mr. Shelford Bidwell, "Experiments showing the Variations caused by Magnetisation in the Length of Iron, Steel, and Nickel Rods, and on the Spectral Image produced by a slowly Rotating Vacuum Tube." 2. Mr. J. Munro, "Note on Electrical Symbols." 3 Mr. J. W. Clark, "Electrolytic Decomposition."

Journal of the Society of Arts.

No. 1,696. Vol. XXXIII.

FRIDAY, MAY 22, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by the kind permission of the Executive Council of the International Inventions Exhibition, in the Exhibition-buildings, South Kensington, on Friday, the 3rd of July next.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. In addition to this, cards will be sold to members of the Society, or to persons introduced by a member, at the following prices:—Until the 20th of June, 5s. each; from that date until the 30th of June, 7s. 6d.; on the 1st, 2nd, and 3rd of July, 10s. each.

The Council, however, reserve the right of stopping the sale of tickets or of raising the price, if it is found necessary, in order to restrict the number of visitors within reasonable limits.

Tickets will only be supplied to persons presenting members' vouchers, (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter, a remittance must be enclosed. Each ticket will admit one person.

Light refreshments (tea, coffee, ices, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase. It will greatly facilitate the arrangements if members requiring additional tickets will apply for them at as early a date as convenient. The members' invitations will be issued early in June. Visitors' tickets can be purchased from the present date.

There will be no admission to the Exhibition on this evening, except by special ticket, and no tickets can be purchased at the Exhibition.

Further particulars as to the arrangements will be announced in future numbers of the *Journal.*

CANTOR LECTURES.

The third and last lecture of the course on "The Manufacture of Toilet Soaps," was delivered by Dr. C. R. Alder Wright, F.R.S., on Monday evening, 18th inst., in which the processes of cutting, shaping, and stamping, and the machinery and appliances employed in the preparation of bars and tablets were described. A classification of toilet soaps, in accordance with the results of chemical analysis, was also given.

The lectures will be printed in the *Journal* during the autumn recess.

EXAMINATIONS, 1885.

The list of successful candidates in the Examinations for the present year has been printed, and is forwarded to the Institutions in Union with the present number of the *Journal.* Copies will also be sent to the various committees for the successful candidates.

PRACTICAL EXAMINATION IN VOCAL AND INSTRUMENTAL MUSIC.

The next Examination in London will be held by Mr. W. A. Barrett, Mus.Bac. (Oxon.), at the House of the Society of Arts, 18, John-street, Adelphi, W.C., during the week commencing 8th June, 1885.

Full particulars can be obtained on application to the Secretary.

Proceedings of the Society.

APPLIED CHEMISTRY & PHYSICS SECTION.

Thursday, May 14, 1885; Prof. Odling, F.R.S., in the chair.

The paper read was—

THE UTILISATION OF A NATURAL CHALYBEATE WATER FOR THE PURIFICATION OF SEWAGE.

By John C. Thresh, D.Sc.

The removal of organic matter from water-carried sewage is a subject of such extreme importance, that a description of any process

actually being employed, whether completely or in part successful, cannot but be acceptable to all who are interested in sanitary matters. On this account, I have undertaken to lay before you this evening particulars of a process of a somewhat novel character, now being worked at one of our inland health resorts, Buxton, Derbyshire.

The novelty of the process lies in the fact that the waters of a chalybeate spring, flowing from an old coal mine in the district, are utilised for effecting the precipitation and purification. Until after the public opening of the works in question, I was unaware of any similar system of sewage treatment having been attempted. Since then, it has been brought to my notice that at Prestwich, near Manchester, an iron water from a neighbouring colliery is caused to mix with the sewage from some forty cottages, and after passing through a number of tanks, the effluent runs into the brook. Whether anything is added besides the iron water I have not been able to ascertain, neither do I know whether the condition of the sewage and effluent has ever been reported upon.

The Buxton sewage is entirely "domestic" in character, there being no factories or works of any kind turning their waste products into the drains. The amount probably averages over 400,000 gallons daily, but varies very considerably, sometimes sinking as low as 300,000 gallons, and at other times rising to 1,000,000 gallons. Considering that the population of the place is only 7,000, these amounts appear enormous, but it must be remembered that during the season (May to November) there are constantly from 1,000 to 5,000 visitors also in the town. Besides this, most of the water from the springs, for which Buxton is famous, finds it way into the sewers, certainly not less than 100,000 gallons from this source being added daily to the sewage, and a considerable amount of storm water also passes into the drains and assists in diluting the sewage. Were it not that during storms the flooding of the sewers brings down an immense amount of offensive matters, the sewage at such times would be excessively dilute. At the present time no change in the drainage is contemplated, but should it appear desirable for any reason to diminish the volume of sewage to be treated, the whole of the bath water could be easily diverted into the river.

Several schemes for purifying—or at least clarifying—the sewage have been tried and abandoned, and for some years the whole has been allowed to run directly into the river without being subject to any treatment whatever. This river, the Derbyshire Wye, rises only a little distance beyond the town through the middle of which it flows; and as in dry seasons the volume of water in the stream is fully doubled by the addition of sewage, its condition in the hot weather is better imagined than described. The adoption of the process of treatment with iron-water and lime, an account of which I am now about to give, has resulted in considerably improving the character of the stream, and there is little doubt that this river will henceforth cease to create a nuisance in the lovely valley through which it flows.

Briefly stated, the sewage is treated by mixing with about one-third of its volume of a natural chalybeate water, to which a certain amount of milk of lime has been added, and allowing the mixture to flow into a series of tanks, in which the precipitated matter collects, whilst the clear effluent flows over a weir at the end into the river.

It will probably conduce to lucidity if the whole process, &c., is described systematically, and in the following order:—

1. Construction of the works.
2. The chalybeate water.
3. Action of this water on sewage.
4. The sewage before and after treatment
5. The matter precipitated (sludge).
6. Cost of construction and maintenance of works.

1. *Construction of the Works.*—The following brief account of the works is taken from a report of Mr. Hague, Assoc.Inst.C.E., the town surveyor, from whose plans and under whose supervision the whole has been constructed:—

The iron-water employed is conveyed by gravitation in especially made earthenware tubes, from a disused colliery at the foot of the Axe Edge hills. At a short distance from the "heading" entrance to the colliery, the iron-water enters a brick receiving tank, constructed on the edge of the brick course nearest the colliery, and is conveyed across the brook in 9 in. metal pipes supported on stone piers. Thence it takes a north-easterly direction to the site of the works, a length of 2 miles 163 yards, and enters a second tank at the rear of the liming rooms adjoining the works, which are situated between the River Wye and the Midland Railway, in Ashwood Dale.

The liming and mixing rooms are erected over the River Wye, supported by a stone semicircular arch, the liming room floor being on a

level with the adjoining highway, and connected with the Board's sidings on the Midland Railway.

The lime required for precipitation purposes is conveyed from the sidings alluded to to the hopper of a patent liming machine. A cistern of 800 gallons capacity receives the pulped lime from the machine, and is supplied with an agitating apparatus, to keep the lime required during the night of a uniform and suitable consistency. Both the machine and agitating apparatus, &c., are driven by an "overshot" water-wheel, 16 ft. in diameter and 3 ft. wide. The water for driving purposes is taken from the Wye, about 500 yards higher up the stream, and conveyed in large sanitary tubes.

Immediately outside the liming and machinery rooms are constructed duplicate brick tanks, into which the main outlet sewer discharges. The tanks are furnished with wrought-iron screening waggons, for the purpose of abstracting the solid and floating matter. After passing through the screening waggons, the sewage runs through a brick conduit into a circular metal chamber, furnished with horizontal paddles, where the iron, lime, and sewage is thoroughly mixed. From here the sewage flows a distance of 50 yards, through an earthenware conduit, to the settling tanks, consisting of two sets so arranged as to work eithe singly or together. Those tanks are constructed of brick walls set in cement, with concrete bottoms, the walls being coped with dressed local grit stone. The length of the tanks is 266 feet, and width 73 feet, and they are capable of holding 400,000 gallons. The formation of the tank bottom is of original design, being 3 ft. 6 in. deeper at the entrance than the outlet, an arrangement which has fully met the object for which it was introduced, that is to retain the sludge at the inlet end of the tanks. The first of those tanks is formed with a brick division wall six feet from the inlet, supported on arches of a similar material, under which the sewage flows into a second tank and thence through the entire series of tanks, with a barely perceptible motion, to the effluent weir sill.

In the centre of the main division wall, at the inlet end of the tanks, a triangular well is constructed for cleansing purposes, and is supplied with duplicate iron run-off cloughs, so arranged as to remove what water remains, owing to the extra depth of the tanks at that end, after the suspended matter has subsided. Outside the entrance tank is a sludge well, fitted with strong chain pump, driven by water power, and with cloughs so arranged as to remove the sludge. It should be stated that the bottom of the tanks are formed with a longitudinal and transverse inclination, with the view of expediting the cleansing process, and minimising manual labour.

2. *The Chalybeate Water.*—The mineral water mentioned as being utilised in this process of sewage purification is derived from a spring which arises in the so-called "old level" mine at Burbage, about two miles beyond Buxton, a mine driven in one of the beds of shale between the mountain limestone and the Yoredale rocks. Until recently diverted, the water flowed into the Wye, very near its source, covering the bed of the river for some distance with a yellow deposit of ochre. The flow of water varies somewhat considerably, but even in the driest seasons there is always an abundant supply, probably never less than 100,000 gallons in the 24 hours. The amount of salts in solution is almost as variable as the flow, undoubtedly due to the fact that the stream in its course from its origin in the mine, to the point where it issues from the hill side, is diluted with water which percolates through the strata above, the amount of such dilution varying of course with the rainfall.

The water has always a faintly opalescent appearance, and if exposed to the air an ochery deposit very rapidly subsides The sample which I submitted to careful analysis, and the results of which are now given, was collected during a somewhat wet summer, but at a time when no rain had fallen for several days previously. As besides sulphates the water contains only a small proportion of carbonates and a trace of chlorides, there is little room for theorising as to the nature of the salts in solution.

Each gallon was found to contain—

	Grains.
Silica	1·44
Ferric oxide	·28
Ferrous sulphate	3·30
Aluminic ,,	1·26
Magnesium ,,	7·44
Calcium ,,	9·01
Sodium ,,	1·99
Ferrous carbonate	3·22
Sodium chloride	·76
	28·70

[The total iron corresponds to 14·8 grains of the crystalline sulphate, and the alumina to 3·6 grains of potash alum.]

From estimations of the iron made at various times, I find that, as a rule, the water is not nearly so strongly chalybeate as this sample, but the analysis gives us an insight as to the nature of the constituents and their relative proportions. It may not be without interest to mention that on the other side of Axe Edge, the hill from which this spring arises, there is another chalybeate spring very much more powerful, containing in each gallon 299· grains of solid matter, of which 174 grains are ferric sulphate, and 73 grains aluminic sulphate. The flow, however, is not nearly so considerable, and to convey it to Buxton would have been a task of some magnitude.

3. *Action of the Chalybeate Water on Sewage.*—When the iron-water is mixed with from two to four volumes of (Buxton) sewage and allowed to stand, a deposit slowly forms, but even after many hours the mixture does not become perfectly clear, in fact it remains cloudy for days. An examination of the supernatant fluid shows that a considerable amount of organic matter remains suspended and in solution, but that some has been removed.

If, however, lime be mixed in proper proportions with the iron-water and sewage, then a more or less flocculent precipitate at once forms, the rapidity with which this settles depending upon the order in which the ingredients are mixed, and the amount of agitation received. The best results in the laboratory were uniformly obtained by adding lime in the proportion of 15 grains to one gallon of the ultimate mixture to the iron-water, and then pouring this into the sewage, and stirring gently for half-a-minute to a minute. Under these circumstances, the flocculæ first formed aggregate together, and fall to the bottom of the receptacle with the utmost rapidity. If the stirring be neglected, the flocculæ are small and subside very slowly; if the agitation be too violent, these large flakes are either broken up or prevented from forming, and clarification is again retarded. Analysis of the effluent, when clear, invariably proves the greater part of the impurities to have been removed in the precipitate. As showing the marked improvement effected by addition of the lime, the result of a typical experiment may be quoted.

For fifteen hours the sewage and iron-water, unmixed with lime, were allowed to flow through the tanks, and at the expiration of that time, a sample of the effluent (1) was taken. The liming machine was now set in motion, and after twenty-four hours, another sample of effluent (2) collected. The results of the examination of the sewage and the two effluents are here compared.

	Organic Ammonia. In parts per Million.	Free Ammonia.
Sewage (mean)	5·	13.
Effluent (1) turbid	1·7	5·
,, (2) clear	·7	3·9

Working at the tanks, it is found that less lime is required to effect clarification than had been calculated to be necessary from laboratory experiments. As nearly as can be ascertained, twelve grains of slacked lime to a gallon of mixed iron-water and sewage secures efficiency, and is the proportion now being added. An excess of lime is distinctly prejudicial; a flocculent precipitate forms, and begins to subside, then the whole volume of fluid gradually becomes opalescent (apparently from formation of calcium carbonate), and then only clears after a considerable lapse of time.

4. *The Sewage before and after Treatment.*—To illustrate the character of the sewage and of the effluent produced, the results of the daily examination of both for one week have been tabulated. The samples were collected alternately in the morning and afternoon :—

Results Expressed in Grains per Gallon.

	Total solids.	Alb. NH_3	Free NH_3		Total solids.	Alb. NH_3	Free NH_3.
Sewage ...	...	·31	·83	Effluent...	23·	·05	·19
,,	37·	·33	1·05	,,	28·	·05	·51
,,	37·	·22	·65	,,	25·	·04	·18
,,	51·	·36	1·16	,,	28·	·07	·24
,,	39·	·23	·76	,,	27·	·06	·27
,,	56·	·32	1·01	,,	26·	·04	·38
,,	37·	·26	1·12	,,	27·	·04	·17
Mean.....	43·2	·29	·94	Mean......	26·3	·05	·28

A more complete analysis of a typical sample of sewage and of the corresponding effluent, yielded the following results :—

	Sewage. Grains per gallon.	Effluent. Grains per gallon.
Total solids (solid at 212° F.)	36·1	26·5
Loss on ignition	13·3	5·5
Chlorine	3·	2·2
Free ammonia	·60	·24
Alb. ,,	·22	·04

	Sewage. Grains per gallon.		Effluent. Grains per gallon.
Hardness, temporary	10·	....	6·
,, permanent	4·	....	11·
Total	14·		17·

Nitrates and nitrites present in only small quantities in both.

Upon comparison, it will be noticed that in the sewage the total solids varied from 37 to 56 grains per gallon, with an average of 43 grains; in the effluent from 23 to 28, with an average of 26. In the sewage the albumenoid ammonia varied from ·22 to ·36 grains, with an average of ·29; in the effluent, from ·04 to ·07, with an average of ·05. The free ammonia in the sewage varied from ·65 to 1·2 grains, average ·94; in the effluent, from ·17 to ·51, the average being ·28.

With regard to the alkalinity of the effluent, I have refrained from expressing this numerically for fear of fostering a misconception. If by alkalinity we mean presence of uncombined alkali (ammonia and lime), then I have never observed the sewage to be alkaline. On no occasion has an alkaline reaction been indicated on adding a little phenol-phthalein as indicator; on the contrary, it has invariably been necessary to add more or less alkali to produce the pink tint. Moreover, the presence of calcium carbonate is always demonstrable by comparing the permanent with the total hardness.

When an indicator, such as methyl-orange, is employed, no acid reaction is exhibited; indeed, a certain amount of acid must always be added before colouration is produced. This, however, does not prove the presence of free alkalies, inasmuch as with such indicators no reaction is obtained until all the carbonates have been decomposed.

This distinction between alkalinity due to presence of free alkali and of carbonates, is one of some importance in treating of sewage effluents, as to whether they are in a fit concondition to cast into a stream; and I have more particularly made reference to it here, because I have seen it stated that the effluent from the Buxton sewage was "distinctly alkaline," and commented upon as though this alkalinity was due to the presence of lime.

The amount of lime salts in solution both in the sewage and effluent may be inferred from the results of the examinations for hardness. As a rule, the sewage varied within the following limits:—

Temporary hardness	8—12
Permanent hardness	4— 6
Total	12—18

The effluent similarly gives—

Temporary hardness	6-- 0
Permanent hardness	10—20
Total	16—20

In treating sewage with lime alone, if sufficient be added to effect anything like clarification, the effluent is almost invariably and truly alkaline, but in the scheme under consideration, a considerable portion of the lime is used up in decomposing the salts of iron, aluminum, &c., in the chalybeate water, a little doubtless is carried down with the precipitate thus produced, without entering into any combination or effecting any decomposition, the remainder attacks the soaps, fatty acids, and free carbonic acid in the sewage, throwing out of solution also an equivalent of calcium carbonate by the withdrawal of the acid gas which had held it in solution. Thus, whilst the permanent hardness is increased, the temporary hardness is reduced, the total hardness being but slightly affected.

Returning to the organic matter in the sewage and effluent, as measured by the free and organic ammonia, in order to ascertain what improvement is due merely to dilution, and what to the action of precipitating agents, we have only to know the relative proportion of iron-water used and make a simple calculation. During the week for which the results of the daily examination of the sewage have been recorded, as near as I can ascertain, the volume of iron-water would be about one-third that of the sewage. Correcting for this dilution, we find the organic ammonia reduced from ·29 to ·07, and the free ammonia from ·94 to ·37 grains per gallon, *i.e.*, the organic ammonia is reduced to less than one-fouth, and the free ammonia to one-third, results which, considering the character of the sewage, must be regarded as satisfactory. With a sewage exceptionally strong (for Buxton), the decrease is very much more marked.

Inevitably from the relative volumes of the sewage and water, the condition of the stream into which the precipitated sewage flows must be largely influenced by that of the effluent. The improvement in the river became apparent almost the moment the works were put into operation. Immediately before the sewage was turned into the tanks, a sample (No. 1) of the river water was taken about 200

paces below, and afterwards a sample (No. 2) when the sewage was running into the tanks and the effluent into the river. Upon analysis these gave the following results:—

Grains per Gallon.

	Free ammonia.	Organic ammonia.
No. 1	·29	·15
No. 2	·09	·02

Showing that the improvement was most marked.

Compared with the action of solutions made to imitate in composition this natural water, it is invariably found that the latter, under the same conditions as to agitation and quantity of lime added, give a more flocculent precipitate, subsiding with greater rapidity, and yielding a brighter effluent than is the case with the artificial water. As previously stated, the best results are obtained by adding the lime to the chalybeate water, and immediately pouring the mixture into the sewage, with due agitation. Frequently the sewage can be quickly cleared in this way, when it absolutely refuses to clear if the lime be added to the iron-water and sewage previously mixed. The probable explanation of this somewhat singular fact appears to be, that the action which takes place during purification is not only chemical but mechanical. Upon adding the lime to the undiluted iron-water, a copious flocculent precipitate at once forms, and when poured into the sewage, these hydrates (and carbonates?) combine with certain of the organic constituents of the sewage, aggregate into large flocculæ, taking up at the same time the matters which are suspended, and carrying the whole to the bottom. When the lime is added to the iron-water, diluted with 2—4 volumes of sewage, the precipitate which forms is only slightly flocculent, and rarely aggregates by agitation; hence it does not free sewage of the matters suspended in it.

Apparently, also, by adding the lime to the iron-water first, a smaller quantity of the alkali is required to effect the purification. This is probably due to much of the lime entering at once into combination with the free carbonic acid of the sewage, and being thus rendered incapable of acting upon such a dilute solution of iron, aluminum, and magnesium salts.

5. *The Sludge.*—Notwithstanding that not a particle of insoluble matter is used in this process, the amount of sludge produced is somewhat considerable, and unfortunately, as yet, I have been unable to persuade the local authorities to take any steps to make it more disposable. At the present time it is simply pumped from the well (by the chain-pump worked by a water-wheel), after draining from the tanks as much water as possible, and carted away to the Board's farm. The members of the Board are sanguine that its effects as a manure will be such, that the local farmers will be glad to fetch it away when the tanks are being cleansed. If such is the case, and they do not care to try and make it into a saleable commodity of any kind, then, so far as they are concerned, the sewage problem is solved. It is suggested that the "destructor" they are about to erect to burn the town's refuse should be so adapted as to dry, and, if necessary, burn the sludge, as the ash, which consists of lime and ferric oxide chiefly, can probably be utilised. As the sludge is apparently not nearly so slimy as that produced by lime alone, it would not be so difficult to convert it into a saleable manure.

As nearly as can be ascertained, the perfectly dry residue from 1,000,000 gallons of sewage and iron-water will be 25 cwts., but as the sludge, as lifted by the pump, contains at least 75 per cent. of moisture, five tons of such sludge would be deposited. Taking the amount of liquid flowing through the tanks to average 600,000 gallons per day, 21 tons of sludge would be formed weekly. This, by drying, would be reduced to six tons, and by incineration to about three tons.

The sludge varies somewhat in composition, but when sufficiently dry to be pulverulent, its average composition is as under:—

Moisture	15·
Organic matter	38·
Oxide of iron and alumina	14·
Calcium and magnesium carbonates	24·
Phosphoric acid	1·
Other mineral matter	8·
	100·

The nitrogen present corresponds to 1·5 per cent. of ammonia.

6. *Cost of Construction and Maintenance of Works.*—The original estimate for the construction of the tanks, erection of three workmen's cottages, conveying the iron-water, laying of tramway, and for machinery, was £3,000. This, however, is likely to be slightly exceeded, but if the cost of the cottages is deducted, £3,000 will more than cover the remainder.

Very little labour is required to efficiently carry on the works; one man being able to

attend to the lime, machinery, and the emptying of the cages in which the larger solids are collected. When the sludge is being removed from the tanks, a little additional help is required. The total cost per annum for labour may be put down at £75. The only additional expense is the lime, the cost of which will be about £80 yearly. The total expense, therefore, including interest on capital, is £275 per annum, made up as follows:—

Interest on £3,000, at 4 per cent.....	£120
Labour	75
Lime	80
Total	£275

Taking the population of the town at 7,000, this involves an annual charge per head of 9½d., or as it is put in the official statement by the Board, "the cost of the system, including the erection and maintenance of the works, will be covered by a rate of 1¾d. in the pound." Put in other words, each million gallons of sewage treated cost the ratepayers £1 5s.

Having given all the actual details of the process as now being worked, I would again, in conclusion, draw some attention to the fact that the action of this chalybeate water differs from that of a mere solution of sulphate of iron and alumina of corresponding strength in the important particulars, that, when mixed with lime (in due proportion) and added to sewage, it precipitates the suspended and dissolved organic matter (1) more rapidly and (2) more completely, removing the whole of the former and considerable portions of the latter. Moreover, in using alumina and iron salts for sewage purification, the best results are always said to be obtained if the sewage is dosed with lime before these salts are added; whereas with the natural water such is not the case, the maximum efficiency being apparently secured by adding the lime to the iron-water, and then mixing with the sewage. If after adding the lime the mixture be allowed to stand a short time before pouring into the sewage, its efficacy is impaired, or even altogether destroyed.

In the natural water, it must be remembered, we have not only ferrous sulphate but also ferrous carbonate, and there is considerable probability that the compound plays a more important part in the purification of water by iron and its salts than has been hitherto suspected. It is well known that the mere immersion of metallic iron in an organically polluted stream tends to purify it, and possibly this may be explained by the action of carbonic acid on the metal, and of the resulting compound on the organic matter.

A series of experiments bearing on this and other points connected with the subject are now being conducted, the results of which cannot be without interest, and may probably be of considerable importance.

DISCUSSION.

Mr. Baldwin Latham said there was nothing particularly new in this process, but he thought it was a mistake to mix the lime-water with the iron-water before the mixture went into the sewage. At the town of Horsham the water supply contained a large quantity of iron, and he found that the whole of that iron could be precipitated by the addition of lime. It appeared, therefore, to him that mixing iron with the lime before passing it into the sewage would produce an inert compound; and all recent experience showed that wherever lime was used, it should be added before other chemical compounds, especially where such compounds were of an acid description. Very great improvements had taken place in many sewage works by simply putting in the lime first before the sulphate of alumina, much less chemical being required, and more satisfactory results being obtained. Although the quantity of chemicals used in this Buxton experiment was large, the expense would be considerable if the same process were applied to a large town, and they had to purchase chemicals. One volume of this material was added to two volumes of sewage. This dilute water, containing no sewage, and from which all the salts were precipitated, would give about twenty-eight grains in the effluent without any chemical, as against twenty-six produced by the process; so that the degree of purification due to absolute admixture was very great, by using this large volume of water from which the material had been precipitated under the action of lime. It was a well-known fact that if you could always command sufficient water to mix with sewage, then no chemical process was required, because one volume of sewage to four of pure water would give an effluent purer on the average than the best results shown by irrigation, which was acknowledged to be the best system. The tank space employed was very large for the volume of sewage stated, and he could not understand how this sewage was so strong as it appeared to be, unless there was some large amount of solid matter in the water supply. If both these tanks were in use, they would contain the sewage for twenty-four hours, which gave a long time for sedimentation to take place. Iron in various forms had been used repeatedly, and from investigatons made some years ago for the Commission on Metropolitan Sewage, it was shown by Dr. Frankland that of all the salts of iron perchloride was the best, but that utterly failed when it came to be tried over a number

of years. At Northampton that process had been adopted in conjunction with lime, but the river became so foul that it had to be abandoned, and the sewage applied to land. In fact, the iron had been almost universally abandoned, one reason being that sludge containing a large amount of iron was supposed not to be so valuable for agricultural purposes. The paper was interesting as recording an experiment; but he feared when the parties in this particular neighbourhood wanted an effluent of a high standard of purity, they would find some other method would have to be adopted. He should like to know what means were taken for regulating the chemicals which passed into these tanks, as he understood they were left to work by themselves at night, when probably the sewage would be less in quantity and more diluted. But as the strength of sewage varied, so should the amount of chemicals vary, and in all the works with which he was connected where chemicals were used there was an automatic arrangement worked by the sewage itself, so that the right volume should be added. Under ordinary circumstances the flow of sewage at one period of the day would be three times as much as the average flow, so that the adjustment of the amount of chemicals was very important. He thought the large number of divisions in the tank was probably a disadvantage, as it would be impossible to rectify a mistake. If too little chemicals went into one compartment it might be nearly filled with raw sewage, which would ultimately pass out in the same state. But if there were no impediments in the tank, it would be possible by large admixture to greatly modify the ill-effects due to bad judgment.

Prof. BISCHOF remarked that when Dr. Frankland made his experiments, and found that perchloride of iron was the most efficacious in purifying impure water, he did not extend his experiments to the ferrous carbonate and hydrate, and he believed that these salts were the most efficient in removing organic matter from water. If, however, these were used, he quite agreed with Mr. Latham that you should not attempt to neutralise the action of the iron by first adding lime. He had tried this by adding soda, and always found the purifying action was considerably decreased. He had had a rather extensive experience in connection with purifying water with iron. Sometime ago he noticed at the Antwerp waterworks that after the water had passed through the spongy iron filter, when it entered the second sand filter—because with potable water you must have a second filtration—peculiar flakes appeared in it, some of which he was able to collect for analysis; they were about the size of half-a-crown, and very much resembled dried leaves. After drying them at a temperature of 120° Centigrade, he found that the dried residue contained 49 per cent. of peroxide of iron, and after that was dissolved with dilute hydrochloric acid, what remained was incinerated, and scarcely left any residue whatever. It appeared to be something of a silicious nature, but it was impossible to test it qualitatively. This was an instance in which an insoluble compound, formed by certain organic acids, such as uric acid and hippuric acid, which all formed insoluble compounds, with ferrous or ferric salts, was separated almost with the same definiteness with which you could separate a crystal. Returning to the paper, it seemed to him there was an over-abundance of iron present, because in very impure water he had found that ten milligrammes per litre of ferrous hydrate, or carbonate, calculated as ferric peroxide, were sufficient to effect purification. He should like to have seen a determination of the ammonia in the ferruginous water, which was very essential, to show the purification effected by the iron and lime. He would also ask whether it had been found that the sewage, after having been thus treated, could be kept for a length of time without undergoing decomposition. This was a most important question, the destructive action of iron on microphytes. That this action took place was now beyond doubt. This had been shown by him in various papers, and the late Dr. Voelcker stated in one of his papers that the presence of a proto-salt of iron in the soil was a sure sign of barrenness. These organisms in sewage were mostly, at any rate, plants, and probably were acted upon in the same way as the higher plants. This view had been confirmed by Dr. Griffiths, who found that by manuring wheat with sulphate of iron it was freed from mildew, but he also found that when he added too much sulphate of iron he destroyed the wheat itself.

Dr. PERCY FRANKLAND wished to remark, in reference to what had been said by the last speaker, that the percholoride of iron, used by his father in the experiments made for the Rivers Pollution Commission, was only nominally perchloride, and that on analysis it was found to consist principally of protochloride. Therefore, on the addition of lime, there would necessarily be principally ferrous hydrate present, and he presumed purification would take place by means of that, and only to a less extent by the ferric hydrate. With regard to this water at Buxton, it was obvious, from the interesting paper which they had heard, that unless there were a very large excess of this purifying material present, it would be exceedingly unsuited for the purification of sewage, because it appeared that not only was the volume very variable, but the composition equally so, so that by no automatic device could it be arranged that the reagent should be duly proportioned to the sewage. This mode of purification by means of iron was a very old one. In fact, the composition of this chalybeate water appeared to be the inverse of that of the reagents which were used in some other sewage works, for instance, at Leyton, where the alumina added corresponded to the quantity of iron present in this water, and the quantity of alumina here corresponded to that of iron there. The proportions used at

Leyton were about 12 grains of lime, $2\frac{1}{2}$ protosulphate of iron, and 10 grains alum per gallon of sewage. Contrary to the practice at Buxton, it was usual there to add the lime in the first instance, and then the other re-agents. It was exceedingly remarkable that a better result was not obtained when the mixture between the iron and the lime took place after admixture with the sewage. It was obvious that this Buxton sewage, however, was about one-tenth the ordinary strength. With regard to the analysis of the sewage before and after purification, he should like to ask Dr. Thresh whether he had taken care that the samples of the effluent should correspond with the samples of raw sewage examined, because the albumenoid ammonia given in the effluent appeared to be very constant, and not to vary with the time of collection; that collected in the afternoon containing the same quantity as that collected in the morning. It was a pity the analyses were not more complete. There were no determinations of organic carbon and nitrogen, which would have rendered the testing of the process far more conclusive. Again, it would have been desirable that the amount of chlorine in the raw sewage and the effluent should be determined, because it was only by taking into account some mineral ingredient, which could not be removed by any reagent, that one could be at all sure of the relative dilution of the sewage before and after treatment. Dr. Thresh appeared to lay a great deal of stress on the disappearance of ammonia in this process, but he should like to ask him what, in his opinion, became of it. He did not see how it could be precipitated, and if not, it was not of much consequence what became of it. Probably it passed away into the air; in fact, in nearly all these precipitation methods, one found a considerable reduction in the amount of free ammonia; whilst if the process was tested in the laboratory, where the mixture was made in a stoppered bottle, the ammonia remained, practically, constant. For instance, in one case he himself had found sewage that contained 5·5 grains of free ammonia per 100,000 parts, when the actual effluent contained only 1·75. But when the same process was tried on a small scale, the ammonia was only reduced to 4·75, or scarcely at all. At any rate it did not appear to pass into the sludge, as the amount of nitrogen found there was much less than the ammonia which had disappeared would yield. It was very desirable that this sludge should be filter-pressed. The great objection to all these precipitation works was the accumulation of sludge, and the nuisance occasioned when it was air-dried, but this was almost entirely abolished if it were filter-pressed. He noticed that the Local Board expected to obtain a sale for the ashes of this sludge, which consisted principally of oxide of iron and lime, but he did not think these materials would find much sale near Buxton, which was already so abundantly supplied with them.

Mr. EKIN said Dr. Thresh had probably two main objects in view in this paper; first, to point out to Local Boards who were fortunate enough to have a chalybeate spring in their neighbourhood what could be done with it; and, secondly, to show that there were indications here of new methods of water purification which were very promising. With regard to the use of chalybeate springs from mines for mixing with sewage, he had experience some years at Worsley, in Staffordshire, where an action was brought by the riparian owners against the Local Board on account of an enormous amount of sewage being poured into a sluggish stream; but there was no difficulty in proving that a small brook, which was fed from a mine near, and was very rich in iron, completely destroyed the sewage in the course of a very short run. He had followed Dr. Thresh's experiments, and really thought there was some hopeful indication in this particular mixture of a solution of the sewage problem. Certainly, as far as they knew, nothing had ever given such an absolutely clear effluent. The effluent at Buxton was exactly like sparkling spring water, a result which he had not seen anywhere else. Mr. Baldwin Latham had rather objected to this as simply an iron process, and he was so well read in all matters relating to sewage that he (Mr. Ekin) was rather surprised to find that he was not quite up to date in objecting to iron for making the sludge useless; for some remarkable results had been lately given before the Chemical Society, which showed that in certain proportions iron was exceedingly valuable as manure. But this was not an iron process alone; there were aluminum, magnesium, calcium, &c., and some experiments of his own, on a small scale, with a similar mixture of salts, seemed promising. Iron salts alone certainly would not give anything like the same results. Dr. Thresh had been very candid about the whole matter, having given in other places ample details of his experiments. He had worked very industriously at the composition of this spring, and had not been able to produce by any mixture of salts what this chalybeate water would undoubtedly do, but he hoped he would still persevere until he found out the secret of this particular combination, whatever it might be. With regard to the cost of the ingredients, he did not know that they need be at all prohibitive. If the Metropolitan Board of Works could afford to deodorise London sewage with potassium permanganate, he thought he could promise that a mixture of this kind would be considerably less expensive. Of course the old difficulty of the sludge cropped up, and he thought twenty-one tons per week for such a small town was rather large. Filter-pressing might be very useful, but that certainly seemed the difficulty with all sewage operations.

Mr. BALDWIN LATHAM said that at Leyton the iron and aluminum process had been abandoned, and

lime and black-ash waste was now used, which had certainly the remarkable property of preventing the sewage effluent undergoing a change.

Mr. MAXWELL LYTE said, as regards the cost of the ingredients, he understood that alumina was one of the ingredients in these chalybeate springs. Hitherto, in the A B C process and others, alumina had been the chief precipitating agent, but his father had taken out a patent for the use of aluminate of soda in conjunction with sulphate of alumina, and by that means was able to effect a saving in the precipitation of alumina, or hydroxide of alumina, of about 33 to 50 per cent.

The CHAIRMAN said anyone who had had much to do with the treatment of sewage would know that there were a great many points on which a very substantial agreement existed, whilst there were other points on which opinions were widely opposed. There could be no doubt of the accuracy of the statement made by Mr. Latham, that sewage irrigation when satisfactorily carried out, did produce a purer effluent than the process of precipitation also supposed to be well carried out. The only question was whether the process of precipitation, in certain cases, effected a sufficient amount of purification for the purpose; and here, again, although there were diverse opinions, the preponderance of opinion was that the process did, in many cases, effect sufficient purification. With regard to the particular precipitant to be employed, he did not gather that Dr. Thresh recommended that every town should carry out expensive engineering works to bring chalybeate water from a distance, when they could get their chemicals in a much more concentrated form, but he did think that great praise was due to Dr. Thresh for having taken advantage of the special opportunity afforded him by the proximity of this natural water. Of course there were advantages and disadvantages attending the use of a chalybeate spring. One advantage was that it could be obtained practically for nothing; but on the other side was the disadvantage that you had to deal with a very bulky material, necessitating increased size of tanks, and you were also dealing with a material somewhat uncertain in quantity and composition. On which side the ultimate advantage lay, could only be decided by experience. It would seem, on the face of it, that this water containing iron in the two forms of sulphate and carbonate, also appreciable quantities of alumina, and large quantities of magnesia, was pointedly fitted by nature for this particular purpose. As regards the order in which the chemicals were mixed, and the observation of Dr. Thresh with regard to the effect of an insufficient or extreme amount of agitation, those were entirely practical questions. So far as his experience had gone, it accorded with Mr. Latham's, that the best results were obtained by the addition of lime first, and the subsequent addition of alumina, or alumina mixed with iron; but how far it would necessarily follow that a similar course would be best where the iron was already dissolved in such a large excess of water, was an altogether different matter. He should have preferred a little more information on one or two points with regard to the nature of the sewage, and the chemical character of the effluent; and he would refer more particularly to the removal of insoluble organic matter by the process. Substantially the whole of the insoluble matter in sewage was capable of being removed by precipitation, together with a certain proportion of the soluble. Authorities differed whether the removal of the soluble or insoluble matter was most important. For himself, he entertained the opinion, which was rather opposed to that of Dr. Frankland, and the Rivers Commission, that the removal of the insoluble matter was the most important of the two, but this was an open question. Still, in dealing with precipitation schemes, it was to be borne in mind that you could certainly effect the removal of substantially all the insoluble organic matter, together with a certain variable proportion of the soluble. There was a great deal yet to be learnt with regard to the best mode of dealing with sewage; and they would all recognise that Dr. Thresh had made an important, ingenious, and, in this particular case, an exceedingly successful addition to their practical knowledge on the matter.

Dr. THRESH, in reply, said Mr. Latham seemed to have misunderstood the motive he had in making this communication. He claimed no originality, but the fact was, that in consequence of the opening of the sewage works being published, he had received innumerable letters asking for particulars of the process and in some cases for minute details. As it was impossible for him to reply to all these letters, some of his friends suggested that the best thing he could do was to read a paper before some Society, and the secretary of this Section had kindly fallen in with that idea. At Buxton, certain schemes had been tried, and having been requested to report upon them, and having condemned some of them, he was asked if he could suggest something better. It was acknowledged that this iron spring was a nuisance, as it covered the bed of the river with ochre, and rendered it unsightly. It then appeared to him that if they could make one nuisance remedy another, it would be a benefit to the town. Consequently, he undertook experiments, and found that by the addition of a little lime they could cause one nuisance to remove the other. Irrigation, of course, was out of the question at Buxton, as there was no land there with a depth of soil exceeding six inches. It was suggested that they should pump the sewage a little distance out of the town, and let it down a water swallow; but no one could say that would be a satisfactory way of getting rid of it. With regard to the effluent keeping without decomposition, some small fish had been kept in a tank, in a mixture of effluent with two volumes of river water, and after lapse of some weeks,

they appeared quite healthy, and there was no perceptible smell from the water. It might be a mistake to mix iron-water with the lime first in the case of artificial mixtures of iron and alumina; but in this case, there could be doubt of the result of his experiments. He did not know that he had hit on the right reason for it, but there was no question that when the lime was added first it did precipitate more rapidly. If you let mixtures prepared in both these ways stand for a few hours, and then examine the effluents, there is no difference with regard to purity, but when the lime was added first, the precipitation took place more rapidly. If you made a solution of sulphate of iron, and made the same experiments, you did not get the same result. With regard to chlorine, he had made a number of determinations, but did not think them sufficiently interesting to record. There was here a natural water which acted in some way which could not be quite explained, but that did not alter the fact that it did so act, and he thought it quite possible that the mode of mixing he suggested was really better than adding lime first to the sewage.

Dr. BISCHOF asked if the effluent was always free from iron.

Dr. THRESH said not invariably. The process was allowed to go on day and night, and sometimes the lime did not drop through the hopper, and then next day you might find a little iron in the effluent, but it did not exceed a very minute trace, and no notice was taken of it. A small trace like that would not materially affect the purity of the river.

The CHAIRMAN then proposed a vote of thanks to Dr. Thresh, which was carried unanimously.

TWENTY-SECOND ORDINARY MEETING.

Wednesday, May 20th, 1885; Sir FREDERICK ABEL, D.C.L., C.B., F.R.S., Chairman of Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Cama, H. D., 171, Palmerston-buildings, E.C.
Case, Edward, Stone-house, Stone-street, Maidstone.
Lowe, Charles, Summerfield-house, Reddish, near Stockport.
O'Neill, Edward Henry, Knowsley-house, Highbury New-park, N.
Simpson, Reginald Wynne, 14, Cornwall-gardens, South Kensington, S.W.
Thresh, John Clough, D.Sc., F.C.S., Buxton.

The following candidates were balloted for and duly elected members of the Society:—

Bottomley, George, Uttoxeter-road, Derby.
Brigg, William, Bank-side, Teddington.
Gibbs, Henry James, Arrandale, Mount Ephraim-road, Streatham, S.W.
Gower, Frederic Allen, 44, Rue François I., Paris.
Smale, Morton, 89, Seymour-street, Hyde-park, W.
Thimm, Carl Albert, 54, Torrington-square, W.C.
Vawser, Robert, 17, Cooper-street, Manchester.
Want, Randolph C., M.A., 13, Sumner-place, Onslow-square, S.W.

The paper read was—

THE AMERICAN OIL AND GAS FIELDS.

By PROF. JAMES DEWAR, F.R.S.

When the Secretary of the Society and I were in America—I left him at Washington to proceed to the oil district, he being engaged on other duties in connection with the present Exhibition—he suggested that I might give some account of the district, and I certainly entertained that view; but, unfortunately, much abler men, who are infinitely better qualified than I am to discuss this subject, have, in the meantime, treated of it before the scientific world. I refer especially to the paper by our honoured Chairman, Sir Frederick Abel, and to that which has been delivered before the Chemical Society by Mr. Boverton Redwood. I was therefore forced to the conclusion that I had better deal with generalities; that is to say, instead of confining myself to details of what I saw in America, I would give a general account of the petroleum industry. I have been very much aided by the recent publication of the most exhaustive monograph which has ever appeared on the subject of petroleum. This monograph has been prepared for the American Government by Mr. Peckham, and is a huge volume which represents nearly one-half of the reports of the tenth census of the United States. A careful study of this monograph will enable the student to reach very definite conclusions upon the subject, because it is there treated in the most elaborate manner. In the first place, the facts with regard to the historical development of petroleum may be summed up as follows:—In past ages petroleum has been gathered from natural springs, and has been used as a medicine, and in a rude way as an illuminating agent. Long ago, it was obtained by artesian borings in China. The development of the coal oil industry, between 1850 and 1860, led to experiments upon petroleum as a substitute for the crude oil obtained from coal, and, in 1859, there came a demand which led to Drake's attempt to obtain petroleum by boring.

The success attending the oil industry in

Pennsylvania during the first four years of its existence, led to the organisation of companies all over the world for the purpose of drilling test-wells wherever springs of petroleum were accessible. In some localities they were successful, in others only partially so, while in the majority of instances they were failures, or were found inferior to the primitive dug wells. The continuously increasing and enormous production of the United States, and the consequent depreciation in value of all the products manufactured from petroleum, has led to the almost complete control of that trade by American manufacturers, Galicia and the Caucasus at the present time being their only competitors, and they only to quite a limited extent.

An examination of a map will show that bitumen occurs on the American continent along a line extending from Point Gaspé, in Canada, to Nashville, Tennessee, and in Europe and Asia along a line extending from Hanover, on the North Sea, through Galicia, the Caucasus, and the Punjab. These are the principal lines. In America, it also occurs on the Pacific Coast from the bay of San Francisco to San Diego; again, from Northern Nebraska to the mouth of the Sabine river, on the Gulf of Mexico; again, from Havana near the western end of Cuba through San Domingo and the circle of the Leeward and Windward Islands to Trinidad, thence westward on the mainland to the Magdalena river, and southward from that point to Cape Blanco, in Peru. In Europe and Asia bitumen occurs on the lower Rhine, and in the Valley of the Rhone; from Northern Italy, following the Apennines to Southern Sicily; along the eastern shores of the Adriatic, through Albania and into Epirus; again along the depression in which lies the Jordan and the Dead Sea; again, along the mountains that border the Valley of the Tigris in the east; again, from Western China through Burmah, Pegu, Assam, Sumatra, and Java; and lastly, in Japan. It will be observed that these lines are, for the most part, intimately connected with the principal mountain chains of the world.

Petroleum occurs in crevices only to a limited and unimportant extent. It occurs saturating porous strata, and overlying superficial gravels; it occurs beneath the crowns of anticlinals in Canada and West Virginia, but does not so occur in Pennsylvania. In the latter region it occurs, saturating the porous portions of formations that lie far beneath the influence of the superficial erosion, like sand bars in a flowing stream, or detritus on a beach. These formations or deposits, taken as whole members of the geological series, lie conformably with the inclosing rocks, and slope gently toward the south-west. The Bradford field, in particular, resembles a sheet of coarse-grained sandstone, 100 square miles in extent, by from 20 ft. to 80 ft deep, lying with its south-western edge deepest and submerged in salt water, and its north-eastern edge highest and filled with gas under an extremely high pressure.

It is further to be concluded that, from whatever source the petroleum may have originally issued, it now saturates porous strata, not of any particular geological age, but runs through a vast accumulation of sediments from the oldest to the newest rocks, in Pennsylvania and West Virginia, embracing all of the rocks between the Lower Devonian and the Upper Carboniferous.

The experience gained in drilling wells also shows the presence of fissures below the surface. Wells are sometimes started, and after passing through several strata, reach one where, in spite of all attempts to remedy the evil, the hole will go crooked, the drill glancing from the rock on the one side of the fissure, and the well, in consequence, has to be abandoned. At the same time, the extent to which fissures exist in the deep beds of oil sands is now believed to have been very much over-rated. The experience gained in sinking deep wells leads rather to the conclusion that in them the drill penetrates a homogeneous solid sandstone, in the pores of which the oil is held under great pressure.

The motion of oil laterally through the oil sands is illustrated by numerous phenomena attending the drilling operation of contiguous wells. It is observed that the wells and springs of water in the superficial strata fail when these strata are penetrated by deep wells. Even artesian wells sunk for water to the second sand are often drained by contiguous oil wells sunk to the third sand, in consequence of the lateral movement of the water through the second sand to the oil well. The capacity of a porous sandstone, or even of the coarse pebble conglomerate constituting the Venango third sand, to hold the vast quantity of oil that has poured forth from some wells has been questioned, but when we consider (1) the strong attraction of existing oils and dry surfaces, (2) the powerful capillary attraction exerted in consequence, and (3) the enormous pressure under which the oil is held in

the rock, and forced out when the reservoir is perforated, there seems to be no reasonable ground for doubting the sufficiency of such a source of supply.

Mr. J. F. Carll has shown by experiments that the pebble sand will absorb from one-fifteenth to one-tenth of its bulk of oil, and further that "the aggregate sum of the pores or interspaces of a sand rock of this kind, as exposed in the walls of a well of $5\frac{1}{2}$ inches in diameter, is equivalent to the area of an open crevice one inch wide, extending from top to bottom of the gravel bed, whatever its thickness may be." He further shows that "On an oil creek there is generally from 30 feet to 50 feet of third sand, and also from 15 feet to 30 feet of stray sand, both locally producing oil. Of this total, suppose only 15 feet is good oil-bearing pebble, we shall then have a producing capacity of 15,000 barrels per acre, or 9,600,000 barrels per square mile, which is adequate to the requirements of the most exceptional cases known."

Dr. Hunt estimates that a layer of Niagara limestone of Chicago (an oleiferous dolomite), 1 mile square, and 1 foot thick, will contain 1,184,832 cubic feet of petroleum, equal to 8,850,069 gallons of 231 cubic inches, and to 221,247 barrels of 40 gallons each. Taking the minimum thickness of 35 feet assigned by Mr. Worthen to the oil-bearing rock at Chicago, we have, in each square mile of it, 7,743,745 barrels, or, in round numbers, 7,750,000 barrels of petroleum.

The question as to the origin of petroleum is one as to which three suggestions have been made. First, that it is due to the continued operation of chemical processes at great depths; secondly, that it is really indigenous to the rocks in which it is found; and thirdly, that it is due to the natural process of distillation. Now, the supporters of either of those views have always some particular data which is certainly favourable to that particular way of regarding it. In the first place the enormous quantities of oil which have been produced from certain localities seem either to show that the supply is connected with enormous underground chambers, or else that there seems to be some means of continuous renewal. The chemical theory, therefore, is able to account for the continual formation of petroleum. On the other hand, either if it is indigenous or produced by the natural process of distillation, it is connected with geological changes which we have no reason to believe are operating at the present moment. Consequently, the theory we adopt bears on the permanence of the supply of petroleum. Now, before giving you one or two illustrations, I may just mention that there are all possible varieties of this fluid varying in character, in density, in boiling point, in solvent properties, and in all the general modes of characterising these activities. Here you have a series which represents a very complete series of the Russian petroleum; crude, purified, with all grades of intermediate boiling points. In front, I have a fine series of natural petroleums, presented by Mr. Boverton Redwood. Now, it is undoubted that the petroleum of different districts does not agree in its uniformity. The petroleum of Canada contains sulphur, nitrogen, and is essentially different from that which occurs in Pennsylvania. In the same way the petroleum of California differs from either. Therefore, the chemical theory would require to be able to produce a very different kind of product at different places, and that of course is conceivable. Still, one would anticipate that if it was some kind of chemical action, we would have greater uniformity in the products than we have. The character of all these bodies is, that in the particular class of the American petroleum, they all belong to that series which we know very well as the paraffin series, and of which solid paraffin is the characteristic. The solid paraffin was discovered by Reichenbach, about 1826, I think, and was first analysed by Gay-Lussac, in 1826. All these hydrocarbons contain the maximum quantity of hydrogen that the carbon can combine with, whereas the petroleum which characterises the Russian field certainly seems to belong to a totally different series. The Baku oil contains members of the benzol series—bodies which we know seem rather to represent derivatives connected with high temperature changes, whereas the American petroleum resembles in its general characters that produced by distillation by Mr. Young's process at a low temperature.

That petroleum is in some way connected with the vastly abundant accumulation of Paleozoic sea weeds, the trunks of which are so infinitely numerous in the rocks, and with the infinitude of coralloid sea animals, the skeletons of which make up a large part of the limestone formations, which lie several thousand feet below the Venango oil sand group, scarcely admits of dispute, but the exact process of manufacture, of its transfer, and of its storage in gravel beds is utterly unknown.

We may alter the composition of these oils by subjecting them to a high temperature. high temperature decomposes the more complex members of this series into gaseous and liquid members of lower boiling point.

In this way we can produce the more volatile from the less volatile, and this can be applied to the production of oils of what we may call low boiling point, from oils of high boiling point. Mr. Young patented this process, but the Americans discovered a somewhat similar process long before—which they call "cracking." The vapour of the condensed petroleum falls back, and comes in contact with petroleum, which is at a much higher temperature, they thus get super-heated, and are partially changed into more volatile products. This "cracked" oil differs from the original in this respect, that it contains a larger proportion of members of the ethylene series. It is the decomposition of the more complex into the less complex. It has been suggested that it is possible that the less complex may be forced into the more complex, and that the recent enormous production of these gaseous oils may, in themselves, account for the production of the fluid, rather than the fluid or solid portions accounting for the production of the gas. The difference is simply that the denser hydrocarbons are produced from the more complex portions, and the bodies which result from high temperature are bodies which belong to a different series, and not to the same we meet with here. In the same way, the chemical theory which has been suggested by the Russian chemist Mendeleef is, that the carbides of the metals may exist at great depths in the earth, and that by the action of steam these are decomposed into the oxide of the metal, and hydrogen combining with the carbon, that produces the gaseous fluid—hydro-carbons. Now we know really that this action does take place. If we take a piece of ferro-manganese which contains carbon manganese and iron, or say, cast-iron, which is well saturated with carbon, and treat it with an acid, then the hydrogen is found to be mixed with hydro-carbon. Therefore, the carbides of the metals may react with the vapour of water and produce hydro-carbons. It is quite true that the suggestion that the carbides of the metals may exist in large quantity is favoured by the fact that we know that the density of the interior of the earth must be considerably greater than the mean density, because the density does go on increasing, and probably it may reach a quantity which is represented by something like twelve times that of water. The probable existence of iron manganese and other metals at low depths is consequently impugned. The view that petroleum is a product of distillation, probably at a low temperature, which has been caused by metamorphic action, seems to fit in best with all the facts we know regarding the distribution of petroleum.

It should be borne in mind, that while this subject is one of speculation pure and simple; it is one that has its valuable consideration outside the domain of scientific inquiry or curiosity, as affecting the sources and duration of supplies of petroleum, its profitable development, and commercial permanence. If petroleum is the product of a purely chemical process, we should not expect to find paleozoic petroleum, of a character corresponding with the simple animal and vegetable organisms that flourished at that period, and tertiary petroleum, containing nitrogen, unstable, and corresponding with the decomposition products of more highly-organised beings; but we should expect to find a general uniformity in the character of the substance, wherever found, all over the earth.

The advocates of the chemical theory affirm that they provide for a process the conditions of which are perpetually renewed. It is thus continuous, and at present active. On the contrary, if petroleum is the product of metamorphism, its generation is coexistent only with that of metamorphic action, an action which we have no reason to believe has been prevalent on a large scale during any recent period. If we accept this hypothesis, the generation of petroleum is then practically ended.

Some of the most remarkable advances which one cannot help noticing in America is the rapidity with which oil wells are sunk, 1,500 or 2,000 feet being pierced in the space of something like a month or two at the most, and the facility and regularity with which this operation is continuously carried on without any of the dangerous accidents which formerly occurred in connection with this enterprise. The drilling, in itself, would really supply matter for an exceedingly interesting paper.

The early method of drilling, with the well full of water, prevented the escape of the oil and gas until the water was pumped out. When the rock is pierced with a hole drilled dry, the effect is similar to the sudden liberation of the safety-valve of a boiler under a full head of

steam, the boiling foaming mass is driven upwards against the forces of gravity, and sometimes shoots high above the top of the derrick. The equilibrium which has been maintained for ages throughout the communicating portions of the rock is suddenly destroyed, and material, gaseous at the ordinary temperature and pressure, but fluid under the enormous pressure maintained in the oil rock, expands and evaporates as it rushes to the surface. This action goes forward, slowly reducing the pressure upon all the communicating portions of rock, until the pressure on the oil filling the rock is only equal to that of the column filling the drill-hole. Considering, then, that the oil is often forced up to the surface from a depth of 1,500 or 2,000 feet, we can calculate from the density of the oil the maximum pressure which may often range from 30 to 50 atmospheres.

The pump is now used to lift the fluid from the drill-hole, the oil being still under the pressure of the gas, ascending between the tubing and casing. The rock is still full of oil, and the pumping goes on, until the pressure of the gas is scarcely sufficient to send any of it to the surface, when a gas-pump is applied at the casing-head to one of the lateral tubes, and the pressure of the atmosphere removed. Still, after all this, there is oil remaining in the rock. As before intimated, the oil and gas mutually dissolve each other and form a homogeneous mass, "the gas being as thoroughly incorporated with the oil as gas is with water in a bottle of soda-water."

This probably explains the enormous proportion of gas along with petroleum. The gas, under this enormous pressure, is exceedingly soluble in these oils of high boiling point. The result is, that as the pressure is gradually relieved, the gas may be said to distil off from a strong saturated solution, and consequently, the volume of fluid in the porous rock, which we were discussing in the case of the fluid petroleum, is not applicable to the volume of gas. We get gas, and although the gas may not be liquefiable, yet we may say it is approximately liquefiable in the particular solvent which dissolves it.

After the oil has stopped flowing, if the well owner does not pump, his neighbours' wells will drain his territory; and if he "pulls out," the law compels him to fill his well with sand, and ruin it for ever, to prevent the public injury resulting from letting down surface-water into the oil sand. There is, therefore, no other alternative presented to the unfortunate possessor of oil territory but to drill and produce, whatever the price of oil may be.

Experience has proved that one well to five acres is as close as they should be drilled. The man who owns a lot has no safety but in getting his oil to the surface, otherwise he is constantly exposed to the risk of having it sucked dry by the well of his more energetic neighbour.

We, as a nation, are very much in the position of the owner of oil territory in regard to our coal supply. In discussing the question of an export duty on coal, Mr. Jevons came to the conclusion that "We must either retract the profession we have made to the world, and the principle we have so recently adopted, or else we must submit to see our material resources exhausted in a shorter period than could have been thought possible." This curve on the diagram on the wall represents the growth of coal consumption in this country from 1854 to 1884. You observe that it is a wonderfully symmetrical curve, and that it has a periodic regularity. For about four years after 1854 there was a very slight increase, then a rapid growth, and again a slight diminution. The minimum periods are about every ten years. The mean position of this curve supports the view originally taken by Sir William Armstrong, that an arithmetical progression was most probably the law regulating our coal output We see that in the near future the quantity of fuel will be small, and therefore we are very much in the position of the oil proprietors: we must exhaust our treasures, or else we shall be behind in the race.

The distribution of petroleum from the oil districts, and the mode of conveyance, is certainly one of the most striking developments of the industry, and a visit would not be complete without viewing a reach of the enormous pipe-lines and pumping-stations which convey the oil from something like 21,000 isolated oil mills, of Northern Pennsylvania, and carry it to Philadelphia, New York, Baltimore, &c. It is pumped from valleys over the hills, the highest elevation being in any one place above 1,500 feet. There are very varied and complicated problems connected with this mode of distribution—not only of pressure, but friction in the pipes. The pumping-stations are distant from twenty to twenty-five miles, and the oil is pumped in from the twenty-mile station in advance into enormous reservoirs of 100 feet in diameter, and 40 feet to 50 feet in height; it is again pumped out for

another twenty-five miles, and so on to Baltimore and Philadelphia. It is remarkable that although complaints have been made in the past of the waste of oil, that comparatively little is allowed to waste. I was surprised that of the enormous outflow of oil which took place when the Philips well was started in September, so little was lost; it was pumped away in a narrow pipe laid at once to the nearest pipe-line, so that even when an enormous rush of this kind occurs there is very little waste of oil.

The problems in hydraulics presented in the construction and management of pipe-lines are many and intricate, and required great courage on the part of those who projected the first line to meet and surmount them. These men had only the quite different problems and experiences met in laying pipes for water to guide them. The pipe-line problems dealt with a fluid varying in density with the temperature, flowing easily in summer and with difficulty in winter through pipes of small diameter, laid hurriedly and frequently changed, often on sharp curves or at right angles, for rapid movement and delivery, and at high pressures, to compensate in part for the friction due to long distances and rapid transmission.

The Trunk lines transport the oil of large areas to the cities of Pittsburgh, Cleveland, Buffalo, and New York, under a high pressure, delivering thousands of barrels daily. They are laid for miles through the forest-covered hills and valleys of Northern Pennsylvania and southern New York, across hills and rivers, on the surface of the ground, or only slightly covered. These main lines are 6-in. pipe, tested to a pressure of 2,000 lbs. to the square inch, and joined with couplings, into which the lengths of pipe are screwed, as are ordinary gas or water-pipes.

Only those firms and corporations under strict business habits really know approximately how many miles of pipes they own, and therefore an accurate enumeration is found to be impossible; but it is safe to say that there are thousands of miles of 2-in. pipe laid for transporting oil owned by the pipe-line companies.

The pumping-stations consist of permanent buildings, a boiler-house, and a pump-house containing a steam and oil-pump combined in one. Many of these pumps are of the Worthington pattern, and are very powerful machines, forcing the oil through great distances, not only over the hills, but against the friction of the pipe conveying the oil—an element of vast importance, as the friction increases enormously as the flow of oil is increased in rapidity. The friction on the 108 miles of 6-in. pipe between Rixford and Williamsport, Penn., is found to be equal to a column of oil 700 ft. in height; *e.g.*, if the pipe were laid on a uniform descending grade of 700 ft. between the two points, and filled with oil, the friction or the adhesion between the oil and iron would prevent the oil from flowing. For these reasons, the pressure carried on these pumps is frequently from 1,200 lbs. to 1,500 lbs. to the square inch.

Along with this admirable mode of distributing the petroleum, and the elegance and accuracy of the workmanship in laying the mains, there are a great many problems which suggest themselves. In the first place, the troubles which are caused sometimes by the plugging of the wells with solid paraffin. This is probably due to the fact that, under the high pressure in which the lighter portions of the naphtha dissolved in the heavier ones exist, the paraffin is more soluble, and consequently, when the expansion of the gas takes place, and the temperature is lowered, the paraffin crystallises and coats the pipe to the extent of often 100 feet. This explains the stoppage of the supply of gas from the gas wells. They are not actually exhausted of gas, but they are simply, for the time being, plugged either with brine, solid salts (such as chloride of calcium, or paraffin. The paraffin is removed by taking out the pipe and melting it. When wells cease to flow, they sometimes apply an exceedingly interesting device, viz., torpedoing, that is to say, they sink something like sixty to eighty quarts of nitro-glycerine, which is an enormous quantity, and would correspond to a very much larger proportion of dynamite, and fire it at the bottom of the well, the effect being to induce a flow of oil for the time. This plan was introduced, I think, in 1865, was found to be satisfactory in some cases, and has been continued. The most interesting point is that when this is fired there is no sound, and no rush of gas from the 2,000 feet bore. There is no apparent production at all of an explosive effect. This evidently loosens the pores, the enormous gas pressure acting locally, probably from the incrustation of solid hydro-carbons, and when this is relieved, it clears the strata and allows the oil again to flow.

Before I go on to speak of one or two other points connected with the distribution and origin of the industry, I should like to see

if we could manage to show you the character of one or two of the liquid hydro-carbons, which are usually gaseous. For this purpose we have compressed two of these hydro-carbons, which are the most typical. These two large iron bottles contain, the one, compressed ethylene, and the other compressed marsh gas.

The marsh gas is the simplest member of this paraffin series. It is a gas which we might say is permanent—that is to say, no amount of pressure will liquefy it under ordinary conditions. What I want to prove is this, that the enormous production of marsh gas which takes place in all these natural gas wells, cannot be accounted for by any supply of the liquid gas. In order to liquefy a gas, we not only require pressure, but we must be able to work below a certain limited temperature for each gas. That limited temperature is called the "critical point." It so happens, the critical point of marsh gas is exactly 100° on the other side of the freezing point. In fact, we require to work below, or just above 100° below the freezing point of water at a high pressure, in order to liquefy this gas. Considering that these gases, which are the chief constituents of natural gas, come in such enormous quantities from depths of 1,500 to 2,000 feet, where the temperature has gradually gone on increasing with the depth, there is no possibility of explaining the supply by any possible liquefaction, because the temperature reached is far above the critical point of either gas. I hope to be able to show you liquid marsh gas, though there is of course some difficulty in doing it in this room. In order to do this we require to liquefy two other gases; first, carbonic acid, which we inject into air, producing a large quantity of solid, which solid we use for the purpose of collecting a quantity of liquid ethylene. This liquid ethylene boils at a temperature of minus 100°. Into that fluid which will boil at 100° below the freezing point of water, we will place a glass tube, into which we are going to compress marsh gas to the extent of 50 or 60 atmospheres, and if we are successful, we may be able to see that it begins to liquefy, and even possibly I may be able to show you the marsh gas in a solid condition. It becomes solid at a temperature of nearly 200° below the freezing point. There you observe the fluid, and on expansion the solid will form. This is the first occasion on which marsh gas, in the liquid and solid form, has been exhibited to a audience.

Here are some of the analyses of the gas, which have been made by the assistant at Mr. Carnegie's works, near Pittsburg. As I have stated, both Sir Frederick Abel, and Mr. Boverton Redwood have exhausted, recently, the petroleum question, and Mr. Carnegie has exhausted the oil wells by an interesting paper, which was communicated last week to the Iron and Steel Institute. However, he was kind enough to send me these analyses before he published them, and I have had this table made from them. The wells all occur within a radius of about sixteen miles of Pittsburg, and there is evidently a clearly defined gas belt, which lies, apparently, at the summit of the anticlinal reach, which supplies petroleum, and there seem to be inexhaustible supplies of gas.

No. 1.

When tested	Oct. 28, 1884.
Carbonic acid	·8 per cent.
Carbonic oxide	1·0 ,,
Oxygen	1·1 ,,
Olefiant gas..............	·7 ,,
Ethylic hydride	3·6 ,,
Marsh gas	72·18 ,,
Hydrogen	20·02 ,,
Nitrogen	Nil.
Heat units	728,746

No. 2.

When tested	Oct. 29, 1884.
Carbonic acid	·6 per cent.
Carbonic oxide	·8 ,,
Oxygen	·8 ,,
Olefiant gas..............	·8 ,,
Ethylic hydride	5·5 ,,
Marsh gas	65·25 ,,
Hydrogen	26·16 ,,
Nitrogen	Nil.
Heat units	698,852

No. 3.

When tested	Nov. 24, 1884.
Carbonic acid	Nil.
Carbonic oxide	·58 per cent
Oxygen	·78 ,,
Olefiant gas..............	·98 ,,
Ethylic hydride	7·92 ,,
Marsh gas	60·70 ,,
Hydrogen	29·03 ,,
Nitrogen	Nil.
Heat units	627,170

No. 4.

When tested	Dec. 4, 1884.
Carbonic acid	·4 per cent.
Carbonic oxide	·4 ,,

Oxygen	·8 per cent.
Olefiant gas	·6 ,,
Ethylic hydride	12·30 ,,
Marsh gas	49·58 ,,
Hydrogen	35·92 ,,
Nitrogen	Nil.
Heat units	745,813

No. 5.

When tested	Oct. 18, 1884.
Carbonic acid	Nil.
Carbonic oxide	1·0 per cent.
Oxygen	2·10 ,,
Olefiant gas	·80 ,,
Ethylic hydride	5·20 ,,
Marsh gas	57·85 ,,
Hydrogen	9 64 ,,
Nitrogen	23·41 ,,
Heat units	592,380

No. 6.

When tested	Oct. 25, 1884.
Carbonic acid	·30 per cent.
Carbonic oxide	·60 ,,
Oxygen	1·20 ,,
Olefiant gas	.6 ,,
Ethylic hydride	4·8 ,,
Marsh gas	75·16 ,,
Hydrogen	14·45 ,,
Nitrogen	2·89 ,,
Heat units	745,591

This diagram represents the volume of air required for combustion, and the quantity of heat-units produced by the various samples. There were something like five different pipe-lines supplying gas to Pittsburg when I was there. The most interesting fact is that the enormous steel works of Mr. Carnegie are supplied with this gas, and you can see 40 or 50 furnaces without any stoker, without any appearance of smoke, with no one evidently in attendance, and everything working automatically. You look at the pressure-gauge, and you see that it is recording a pressure of something like 75 lbs. to the square inch. Of course, the pressure at the well was greater; they cannot use all the gas, and it is passed on to the next works. The use of this gas, to a limited extent, has been known since 1840, and certain places have used it for lighting. Accidents occurred, and undoubtedly it is dangerous, from the fact that it has very little smell. It differs from our coal gas in that respect, and in this way, unless the pressure is equalised, it is liable to escape, and so form an explosive mixture. There are certain differences, which you see pointed out, in the diagram on the wall, between the coal gas and natural gas. Coal gas explodes with about six volumes of air to one of gas, whereas six volumes of air does not at all produce an explosive mixture with this natural gas; it requires ten volumes of air to explode natural gas, whereas six volumes is enough for coal gas. This gas is produced seemingly in inconceivable quantities. It has in many cases gone on blowing off from old wells for a period of ten, twelve, and even twenty years. Some have actually produced thirty million cubic feet per diem. When we begin to talk of millions of anything, it is inconceivable to the human mind, so that I will put it in this way, in order to show you the magnitude. Let us consider the enormous quantity of coal gas wanted in London for our daily supply. If we had two of these gas wells, yielding 30,000,000 cubic feet, that would be sufficient to supply the whole of London with gas; and from nine to ten wells would be sufficient to supply the whole consumption of gas in Great Britain. Therefore, with this enormous storage of fuel round Pittsburg, which is so lavishly supplied with coal (because the darkness of Sheffield is really bright sunshine to Pittsburg, from the coking operations), it is not at all unlikely that, within a very few years, this coal-charged atmosphere will be materially improved. All the more important works in Pittsburg are now able to use this natural gas. I visited the well sunk by Mr. Westinghouse (the inventor of the railway brake), in his back garden, near Pittsburg.

I heard a howling sound going on, which proceeded from the well. On applying a lighted sponge to the top of the projecting iron pipe, a huge flame of 60 feet in height shot up. The gas goes on blowing off at an extraordinary rate, yet a remarkably constant pressure is maintained, and I need not say that this enormous expansion is attended with considerable reduction of temperature, so that near the top there is an ice coating on the whole of the pipe. During the production of the gas one might use it as an admirable freezing machine, apart from its great power as an antiseptic agent. This diagram on the wall gives you some idea of the heat-units yielded by one cubic foot of gas, and the cubic feet required to evaporate one pint of water. The cubic feet of hydrogen required is nearly 3, and water gas 3½, blast furnace gas 10·38, carbonic oxide 3·13, and marsh gas ·938.

The next diagram represents the produc-

tion of petroleum in America, which evidently reached a climax for the time being in 1882, when it reached the enormous quantity of 31,000,000 of barrels. The only other field which bears any comparison with this field is undoubtedly the remarkable field described by Mr. Redwood. The output of Russian petroleum has reached one-third that of the United States. The character of the oil is different; it does not contain anything like the same quantity of what you may call burning oil, but yields a very high-class lubricating oil, and the higher boiling point oils, although they do not contain solid paraffin, contain vaseline, and are exceedingly useful as liquid fuel. The only field which may be regarded as a competitor to America is undoubtedly the Russian oil field. These two curves represent the growth of American petroleum and the Russian oil industry.

Here is another diagram, on which you see the quanity of exports and the quantity of petroleum used in different countries:—German ports, 100 million gallons; England, 70 million gallons; Belgium, 43 million gallons; France, 39 million gallons; East Indies, 31 million gallons; Holland, 21 million gallons; Italy, 18 million gallons; Austria, 18 million gallons; India, 17 million gallons; Spain, 13 million gallons.

The daily demand for petroleum is something like 40,000 barrels. At present the Americans have stocked something like forty million barrels, which is equivalent to something like a three years' supply, that is to say, suppose the American oil-fields stopped to-morrow, there would still be from two to three years' supply stored in the numerous reservoirs of the United States pipe-lines. What I have already said explains why, even though there is such an enormous quantity of petroleum stored, the production of oil goes on incessantly, and that it is apparently not diminishing, but increasing. When I left America, the great sensation was the Philip Well, and I was astonished to receive, upon landing, a letter from a friend, from which I extract the following sentence:—"Since you sailed, there has been the Christy Well, which yielded double the quantity of the Philip Well, and now comes the Armstrong Well, in the same district, that far surpasses either. Crude petroleum went down to 59 cents., and the whole stock in the United States declined in valne more than two millions of dollars in two days."

It is interesting in connection with the genesis of petroleum, just to refer to the explanation of the origin of it from woody fibre. It is also interesting to consider at what rate we are using our coal in comparison with the rapidity of vegetable growth over an equal area. Coal being produced by the transformation of cellulose, it is easy—from the quantity of wood which can be produced in a given area, or from a given surface of green leaf—to ascertain what this would be, and, shortly, it is this. When we compare the total energy which the sun gives on the area of the leaf in the quantity of store power which the leaf gives us in the form of cellulose or storage, we find we have only one out of 132; that is to say, we have it in the ratio of 1 to 132; there is 132 times the energy available, but we can only manage to secure one of them. That might be said to be an exaggerated estimate, because the efficiency is not due to the total energy, which is largely composed of heat, but is essentially due to the light portion.

Let us take the energy of the light portion alone. If the light portion of the spectrum is considered, the ratio is 1 to 43—that is to say, we only economise one forty-third part of natural sun-light. Now, this is not the efficiency of a good, or even of an old bad-working, steam-engine. One to 42 would be considered a serious loss of energy, apart from the enormous surplus which is evidently wasted in space, of which we cannot conceive any use in the meantime, unless other worlds can economise it. We see that in the efficiency of vegetation, we have nothing like the efficiency we have in mechanical appliances such as the gas-engine.

The development of the oil territory proceeds, after its existence has been demonstrated, without regard to any other interest. The derrick comes like an army of occupation. The farms, fields, orchards, or gardens, alike are lost to agriculture and given to oil, and on the forest-covered hills the most beautiful and valuable timber is ruthlessly cut and left to rot in huge heaps wherever a road or derrick demands room, whilst here and there the vast storage tanks stand, a perpetual menace to everything near that will burn. Nothing I ever beheld reminded me so forcibly of the dire destruction of war as the scenes I beheld in and around Bradford. But the wave of desolation passes over, and nature changes the scene in the same manner as she gathers and restores the ruins of battlefields. The famous Pithole city, which in 1865 was, next to Philadelphia, the largest post-office in Pennsylvania, showed

a farmer ploughing out corn where the famous Shearman Well had been; a waving field of timothy where the Homestead Well had been; the site of the famous United States Well hardly to be found by one who had known it all through its career; and of the city, there remained but fifteen or twenty houses, rapidly tumbling to decay, but not an inhabitant. The country around this scene of so much activity fifteeen years ago is growing up to forest, and is not now valued at an amount equal to a year's interest on the valuation of that time. The Oil Creek region has now returned to the condition of an agricultural and manufacturing community. On the lower Alleghany, in Clarion and Butler counties, the production of oil has become much lessened in importance, and the wreck of abandoned derricks in many localities present a dismal picture. The Bradford field is now in fully developed activity, and the destructive subordination of every other interest is everywhere painfully apparent. Yet the towns that are the result of the oil industry are scarcely more substantial than a military camp, and are infinitely less inviting in their appearance.

Looking towards the past it may be said that petroleum has become the light of the world. It is fast displacing vegetable and animal oils as a lubricator on all classes of bearings, from railroad axles to mule spindles. It is also displacing animal and vegetable oils where such oils are liable to spontaneous combustion; it is becoming one of the most largely used materials for fuel in stoves, both for cooking and for heating purposes; it is very successfully used for steam purposes where other fuel is scarce and petroleum is plenty; it is found to be available in the metallurgy of iron, and is likely to be in demand for the production of pure iron for special purposes; its merits have been long recognised in medicine, and it is rapidly becoming a necessity in the form of petroleum ointment; in fact, petroleum has become one of the indispensable needs of civilised man, and ministers to his wants in such a multitude of forms, and under such a variety of circumstances, that it may be safely said that it ameliorates the conditions of his struggle with external nature, adds comfort to health, and soothes in sickness, prolonging his active life, by extending the day into the domain of night, over all that portion of the earth's surface accessible to commerce.

It is to the Americans the merit belongs of having given to petroleum this last right of citzenship among the industries. The native talent that leads them to regard the useful aspect of everything; above all, the feverish but patient activity, seconded so well by a happy temperament, has served them marvellously on this occasion.

DISCUSSION.

The CHAIRMAN said he was sure the meeting would join with him in thanking Professor Dewar for his interesting paper on the present extent of the use of petroleum; for the really remarkable experiments with which he had illustrated the paper; and for the valuable information collected in the diagrams on the wall.

Mr. BOVERTON REDWOOD said it was never very easy to say anything new on the subject of American petroleum, or indeed upon any subject after it had been dealt with by Professor Dewar. With regard to the use of natural gas as fuel, it had been stated that the cost of a pipe-line to convey it from the gas-fields to Pittsburg was not less than £27,000 sterling, and it was evidence of the great faith which those who used that gas had in the permanence of the supply, that so much capital should have been invested, and that further investment should still be going on. It was reported that, at the end of the present year, there would be no less than eight pipe-lines conveying the gas from the gas-fields to Pittsburg, the diameters of the pipes ranging from 5½ inches to as much as 12 inches. In the process of boring for gas or oil, it often happened that when the supply was struck, the outrush was of sufficient violence to sustain the weight of the boring tools, and even in some cases to eject them from the bore, though the drilling tools weighed about a ton. Even after the first outrush, the pressure of the gas was as much as 200 lbs. on the square inch. The use of petroleum gas as fuel probably dated from pre-historic times; there was no reason to doubt that it was employed for lime burning in the neighbourhood of what were called the "eternal fires" in the Apsheron Peninsula, on the shore of the Caspian Sea, in the time of Zoroaster, who lived 600 years B.C., just as it was at the present time. He saw last year lime-burning carried on in that neighbourhood, by the use of the natural gas, in the most primitive fashion; there was plenty of limestone about, and it was simply necessary to loosen the surface of the soil and apply a light to the gas. When a new oil town was laid out, one of the first works undertaken was the lighting of the streets, and it was customary to lay a main through them from the nearest gas well, and to insert in it as many vertical pipes (of considerable diameter) as might be required. The

gas was lighted, and remained burning day and night, yielding flames of large size, though of no great luminosity. The value of natural gas as a heat producer was well known. By the combustion of 1 lb. (23·5 cubic feet) of the gas, a practical evaporation in a steam boiler of over 20 lbs. of water had been obtained. But whatever might be the value of gaseous fuel, it was not applicable to the mercantile and belligerent marine like liquid fuel was. Anyone who had travelled on the Caspian Sea in an oil-burning steamer, must have recognised that there was a great field for the employment of liquid fuel on board ship.' Instead of a number of toiling stokers being required, one attendant could look after the taps which supplied the liquid to the boilers; no dust was created by it; the oil could be taken on board with great rapidity, and it occupied but little space. Mr. Nobel's ingenious apparatus gave a practical evaporation of 14½ lbs. of water per 1 lb. of petroleum residuum, as compared with 7 to 8 lbs. of water per 1 lb. of fuel when coal was used in the same of diplomacy; and it would be well if part of the boiler. The Russians were as much a-head of us in the use of liquid fuel as they appeared to be in the art recently voted £11,000,000 could be applied in making experiments in the use of liquid fuel for torpedo and other vessels. Professor Dewar had mentioned the Armstrong well as being the most productive in the United States. It yielded about 260,000 gallons of crude petroleum in the twenty-four hours; but there had been many wells struck in the neighbourhood of Baku, on the Caspian Sea, which had yielded very much larger quantities. One which he saw opened there sent up a solid stream of oil, more than a foot in diameter, to a height of 100 feet. The fame of that well, however, was totally eclipsed by the celebrated Droojba fountain, which for four months was quite uncontrollable, and ejected the petroleum to a height of between 200 ft. and 300 ft. The oil thrown out during that period would have been worth, in the United States, £700,000 to £1,400,000 sterling; but in contrast with what Professor Dewar had told them of the appliances at hand for securing and tanking the oil thrown out by the Philips well, there were no appliances at the Droojba well, and, consequently, the oil was not only lost, but was a source of further loss, from its flowing over the district. Quantities of sand were also thrown up, which even buried some of the engine-houses in the locality, and many claims were made on the owners of the well for damage thus done. Professor Dewar had pointed out the very great differences in petroleums obtained from various localities, and in that connection it was worthy of note that the geological strata in which those petroleums existed were not in all cases the same. The Baku petroleum, for instance, was found in the Miocene formation, which might be called a geological juvenile compared with the Silurian and Devonian formations, in which the oil existed in the United States and Canada. He had recently examined a number of samples of petroleum from Wyoming, which resembled Russian petroleum, in yielding a product well adapted for use as fuel. A large quantity of petroleum of a similar character was, he believed, to be obtained in California. Whatever we might think as to the exhaustion of our coal supply in this country, it was believed in America that the petroleum deposits there would not be exhausted for ages.

Captain CURTIS said that Admiral Selwyn, at a lecture he delivered at the United Service Institution, stated that he had evaporated 36 lbs. of water with 1 lb. of oil. Weight for weight, this crude oil was six times as efficient as coal. Torpedo boats with 20 tons of coal would steam 2,000 miles at the rate of 10 knots an hour, but with an equivalent weight of oil, they would steam 12,000 miles. When oil came to be used for navigation, no doubt it would go up considerably in price, and the Americans might hold it, and stop the supply, so that it would be well for us to seek for supplies from our own colonies, and at home. As to its small luminosity, he would like to know whether that would be increased by more perfect combustion. Admiral Selwyn had shown that there was no smoke from burning the oil. It was difficult to understand why the Government did not have some torpedo boats built to test these experiments.

Professor DEWAR, by an experiment, showed the effect of the gas flame at a pressure of 45 atmospheres.

Dr. ARMSTRONG, F.R.S., said whatever theory might be held with regard to the initial character of the action by which petroleum was formed, it was not a recent product, assuming it to be the product of the decomposition of anything we were now acquainted with. All the petroleums which had been examined were free from hydro-carbons of the ethylene series, which would invariably have been present had this been the case. They must, therefore, have been produced under such conditions as to cause the disappearance of those hydro-carbons. Up to the present time, no chemical change had been discovered which gave such a product as petroleum. The complex nature of paraffin was well known from the researches of Professor Thorpe and Mr. Young. In the different varieties of petroleum they were dealing with products obtained at different temperatures. One remarkable feature in this connection was the almost complete absence of solid paraffin in Russian petroleum, whereas the American contained a fair proportion in the solid state.

Dr. PERCY FRANKLAND, referring to the analysis of natural gas found in America, was of opinion that the nitrogen in it was not derived from atmospheric air.

When nitrogen was found in ordinary coal gas, and there was not a corresponding quantity of oxygen, the inference was to be drawn that the nitrogen came, not from the coal, but from the air; because in the distillation and the subsequent processes of purification the oxygen would be removed. But, with regard to petroleum, there was no likelihood of any change of that kind taking place. As to obtaining a larger yield from these wells by the use of torpedoes, it might be worth trying whether a larger yield of water might not be similarly obtained from artesian wells. In the case of these wells, water was almost wholly derived from fissures, and it rarely happened that the wells struck one of them. By the use of torpedoes a great disturbance of the subterranean strata would probably occur, and the fissures would thus be reached.

Mr. Shippey referred to a small petroleum engine now running at the Exhibition, the invention of Mr. Dawson, the chief engineer of the Northern Railway in France. He suggested that a great source of wealth had hitherto been lost in this country in the waste gas from our coal-fields. A large amount of available fuel was going to waste in the up-cast shafts of our mines in England, which could be thoroughly well utilised. With regard to that waste of inflammable gases in our coal mines, he would not hesitate to say that we had over £1,000,000 sterling a year going to waste in the up-cast shafts. One great difficulty hitherto had been to obtain those gases free from admixture with air, but by tapping them in the up-cast shafts, it would be very easy to store them, as was done in the gasometers.

Mr. Parker said that petroleum had been accidentally discovered at a place near Grenoble, by a chance visitor, who had resided for some time in the petroleum districts of America. He bought the whole of the land about the place, and the workings were now going on. He had very nearly arrived at the *couche* of the petroleum, having driven down 139 metres. The quantity of gas was increasing, and he expected to be able to light Grenoble and several of the neighbouring towns with it.

Prof. Dewar, in replying to the remarks which had been made, showed an experiment to prove that the temperatures of solidification of the American and Russian oils were very different. With regard to the sufficiency of oil for naval purposes, the experiments of Mr. Nobel and of Sir Frederick Abel, at Woolwich, showed that coal, being equivalent to an evaporation of 7½ lbs. of water, petroleum gave an evaporation of 13 lbs., very nearly in the ratio of two to one; and Mr. Nobel had now, with a large surface of flame, obtained the result of 14½ lbs. to 7 lbs. The Americans only suggested the use of petroleum as an emergency fuel, in time of war; it was not intended to employ it continuously. The Russian petroleum residue was used continuously as fuel on all the Russian railways, extending now even to the frontier of Afghanistan. Its economy was enormous, requiring little superintendence or skilled labour. Another advantage was that it could be instantaneously put out. Americans suggested that ships should be built with large holds, as Mr. Nobel has constructed his steamers for the Caspian, for storing fuel, in addition to the coal supply, so that when steam had to be got up very rapidly, the petroleum could be used. He had not been able to procure details with regard to the French well mentioned. Similar attempts were being made in Italy at present, but they were in much the same position there also as had been described in the other case—they had obtained gas, but no oil. The late Emperor had induced Professor Deville to examine the petroleum, and we certainly owed a great debt of gratitude to France in this matter. He had no hesitation in saying that the main credit for the first industrial adaptation of the schists for oil purposes, on a manufacturing scale, was due to France. With regard to the application of these gas wells, there were two places where a very fine lamp-black was made in that way, but he had unfortunately not been able to get access to the factories. The Standard Company had, however, given him every facility for seeing their works, and it was simply astounding to see a machine turning out 4,000 boxes a day with only two men standing by it; all the nails were put in automatically, and as fast as the wood was put in, the boxes completely made were thrown out. In another factory, which he had also been unsuccessful in getting into, very fine carbons for the electric light were similarly made.

The Chairman, in proposing a vote of thanks to Professor Dewar, said with regard to the utilisation of the waste gases from our coal-fields, it was difficult to see how the air mixed with them was to be abstracted, though future science might furnish some chemical or physical means of doing it. Regular supplies came off from some of the blowers. These gases always contained a large proportion of nitrogen, which was not derived from the air, and occasionally small quantities of ethylene had been found in them. They were altogether unaccompanied in any place by liquid products, and were, therefore, quite distinct from the oil gases obtained in America. As to the use of liquid fuel, it had been so completely brought into practice abroad, and especially in Russia, that it was a matter for regret that at the present time we had not in some of our smaller craft, in which space was of so much importance, the means of storing liquid fuel. Petroleum was a much more efficient fuel than coal, even under carelessly carried out conditions, and looking at the comparatively small bulk of the material, the ease with which it could be used with very slight modifi-

cations in ordinary steam-generating apparatus, the readiness with which manual labour was dispensed with, it was to be hoped that England would recognise the advantages of the use of liquid fuel in war steamers. He invited the meeting to join with him in thanking Professor Dewar for his able and interesting address.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The juries for the various groups of the Exhibition are now commencing their work. The first meeting of a jury took place on Wednesday last, when Jury C, dealing with Groups 3, 4, and 5 (Engineering, &c.) met. Jury A (Agriculture, &c.) meets to-day, and several other juries will meet next week.

The following is a list of the juries:—

Jury A. Group 1.—Agriculture, horticulture, and arboriculture.

Jury B. Group 2.—Mining and metallurgy. Group 16.—Fuel, furnaces, &c.

Jury C. Group 3.—Engineering construction and architecture. Group 4.—Prime movers, and means of distributing their power. Group 5.—Railway plant.

Jury D. Group 10.—Machine tools and machinery. Group 11.—Hydraulic machines, Presses, Machines for raising heavy weights, weighing, &c. Group 12.—Elements of machines.

Jury E. Group 6.—Common road carriages, &c.

Jury F. Group 7.—Naval architecture.

Jury G. Group 9.—Manufacture of textile fabrics. Group 18.—Clothing.

Jury H. Group 13.—Electricity. (Class 151, Group 28, "Electrical Apparatus," will also be referred to this jury).

Jury J. Group 14.—Apparatus, processes, and appliances connected with applied chemistry and physics. Group 15.—Gas and other illuminants. Group 17.—Food, cookery, and stimulants. Group 28.—Philosophical instruments and apparatus (with the exception of Class 151, Group 28, "Electrical Apparatus").

Jury K. Group 19.—Jewellery. Group 22.—Furniture and accessories—fancy goods. Group 23.—Pottery and glass. Group 24.—Cutlery, Ironmongery, &c.

Jury L. Group 20.—Leather, &c. Group 21.—India-rubber and gutta-percha, &c.

Jury M. Group 25.—Fire-arms; military weapons and equipment; explosives. Group 8.—Aeronautics.

Jury N. Group 26.—Paper, printing, bookbinding, stationery, &c.

Jury O. Group 27.—Clocks, watches, and other time-keepers.

Jury P. Group 29.—Photography.

Jury Q. Group 30. — Educational apparatus. Group 31.—Toys, sports, &c.

DIVISION II.—MUSIC.

Jury R. Group 32.—Instruments and appliances constructed or in use since 1800. Group 33.—Music engraving and printing.

NOTE.—Group 34 ("Historic Collections") will not be referred to the juries.

Notice will be sent to the exhibitors in the different groups when their jury commences its work, and a second notice to each exhibitor, informing him of the probable date when the jury will inspect their exhibits.

BRITISH ASSOCIATION.

The fifty-fifth annual meeting of the Association will be held at Aberdeen, in September. The first meeting of the General Committee will be held on Wednesday, September 9, at 1 p.m., for the election of the president and sectional officers. The General Committee will meet again on Monday, September 14, at 3 p.m., for the purpose of appointing officers for 1886, and of deciding on the place of meeting in 1887. The concluding meeting of this committee will be held on Wednesday, September 16, at 1 p.m., when the report of the committee of recommendations will be received.

The first general meeting will be held on Wednesday, September 9th, at 8 p.m., when Lord Rayleigh, D.C.L., F.R.S., will resign the chair, and the Right Hon. Sir Lyon Playfair, K.C.B., M.P., F.R.S., President-elect, will assume the presidency, and deliver an address. On Thursday evening, September 10, at 8 p.m., a soirée; on Friday evening, September 11, at 8.30 p.m., a discourse on "The Electric Light and Atmospheric Absorption," by Professor W. Grylls Adams, F.R.S.; on Monday evening, September 14, at 8.30 p.m., a discourse on "The Great Ocean Basins," by Mr. John Murray, director of the *Challenger* Expedition Commission; on Tuesday evening, September 15, at 8 p.m., a soirée; on Wednesday, September 16, the concluding general meeting will be held at 2.30 p.m.

The following is a list of the sectional officers:—*A*—Mathematical and Physical Science.—President, Professor G. Chrystal, M.A.; Secretaries, R. E. Baynes, M.A.; R. T. Glazebrook, M.A., F.R.S., Professor W. M. Hicks, M.A. (Recorder), Professor W. Ingram, M.A. *B*—Chemical Science.—President, Professor H. E. Armstrong, Ph.D., F.R.S.; Secretaries, Professor P. Phillips Bedson, D.Sc., F.C.S. (Recorder); H. B. Dixon, M.A., H. Forster Morley, M.A., D.Sc., F.C.S., W. J. Simpson, M.D. *C*—Geology.—President, Professor J. W. Judd, F.R.S., Sec.G.S.; Secre-

taries, C. E. De Rance, F.G.S.; J. Horne, F.G.S.; J. J. H. Teall, M.A., F.G S.; W. Topley, F.G.S. (Recorder). *D*—Biology.—President, Prof. W. C. McIntosh, M D., LL.D., F.R.S. L. and E., F.L.S.; Secretaries, W. Heap; J. Duncan Matthews; Howard Saunders, F.L.S. (Recorder); H. Marshall Ward, M.A. *E*—Geography.—President, Lieut.-General J. T. Walker, C.B., R.E., F.R.S.; Secretaries, J. S. Keltie; J. S. O'Halloran; E. G. Ravenstein (Recorder); Rev. G. A. Smith. *F*—Economic Science and Statistics.—President, Professor Henry Sidgwick, M.A., Litt.D.; Secretaries, Rev. W. Cunningham, B.D., D.Sc.; Professor H. S. Foxwell, M.A. (Recorder); C. McCombie, M.A.; J. F. Moss. *G*—Mechanical Science.—President, Benjamin Baker, M.Inst.C.E.; Secretaries, A. T. Atchison, M.A., M.Inst.C.E. (Recorder); F. G. Ogilvie, M.A.; E. Rigg, M.A.; H. T. Wood, M.A. *H*—Anthropology.—President, Francis Galton, M.A., F.R.S.; Secretaries, G. W. Bloxam, M.A., F.L.S. (Recorder); J. G. Garson, M.D.; Walter Hurst, B.Sc.; A. Macgregor, M.B.

NOTES ON THE VARIETIES OF GUTTA-PERCHA.

By James Collins.

In a previous article* I reserved a more complete enumeration of the varieties of gutta-percha for a future occasion. In the present instance, I only give those which I have been able to examine personally; other lists which I have by me require yet further examination and comparison, and fuller materials than at present at my command. Many, too, of these names may prove synonymous, and the really valuable varieties may prove to be but few in number.

1. *Dichopsis gutta.*—Bentley and Trimen's "Medicinal Plants," plate 167. Synonym—*Isonandra gutta*, Hooker, "London Journal of Botany," vi. 463, t. 16, &c. Vernacular names—Gutta Tabán; Gutta Percha; Gutta Niato (Sarawak); Gutta Percha Durian (Sumatra); Nyatoe Balam, or Balam Timbaga (Bleekrode); Gutta Balam Durian (Borneo); Dadauw (Banka); Mazerwood tree (English). Geographical distribution—Formerly in Singapore in abundance, but only one or two preserved as curiosities; Malacca and Malay Peninsula, as far north as Pérak; Sumatra; Borneo and other adjacent islands. In Helfer's collection of Andaman and Tennaserim plants at Kew, there is a specimen of this plant. Remarks—Gutta, or as it is variously written, gutah, gatta, gittá, gattá, is the Malayan term for gum or juice; percha (pronounced soft as in peach, not hard as perka) accentuated variously as pârcha, pertja, perchá, is the name of the tree, hence the term may be translated "gum of the percha tree." Recently, it has been suggested that percha means strips or fragments, so called from the way the gutta hangs from the incised trees, but this seems too far-fetched. The old name of Sumatra was Pulo or Pulau Percha, meaning "Island (Pulau) of the Percha Tree." Tuban, túban, tábán is also the name of a tree, and according to Logan a new word has been added to the Malay language, viz.:—Menábán (Men[t]ábán), signifying collected gutta taban. The greater number of Malay nouns admit of conversion into verbs by the addition of a prefix. The tree is often compared to the Durian tree, *Durio zibethinus*, in its general appearance, and I have classed the Dutch varieties of Gutta Durian under it, as both specimens and accounts agree. Whilst in Singapore, I was fortunate enough to procure a fruiting branch, and also to prepare a little gutta from the same identical tree as the specimens from which Sir W. J. Hooker drew up his description were obtained. These specimens are now at Kew.

2. *Dichopsis gutta*, var. *oblongifolia.*—Synonym—*Isonandra gutta*, var. *oblongifolia*, De Vriese, Pl. Ned. Bat. Orient; *ib.* De Handel in Getah-Pertja, Leyden, 1856, with coloured figure. Remarks—This variety found in Borneo differs chiefly in having oblong instead of obovate-oblong leaves.

3. *Dichopsis Macrophylla.*—Synonym—*Isonandra macrophylla*, De Vriese. Vernacular name—Ngiato putih (white gutta). Remarks—Mr. Motley, who collected a specimen of this at Bangermassing, Borneo, describes it as a large tree, with white and soft wood, and with whitish green flowers. The flowers had so strong an alliaceous smell, that he could hardly support the smell whilst drawing the plant. It yielded a second-rate gutta-percha.

4. *Dichopsis Mottleyana.*—Synonym—*Isonandra Mottleyana*, De Vriese. Vernacular name—Kotian. Remarks—Mottley, who found this tree also in Borneo, remarks, "A very tall and straight tree, with smooth reddish-grey bark, reddish within, yielding when wounded a copious flow of milky juice, which hardens to a white waxy resin, brittle when old, but readily softened by heat. Wood, reddish-white, woolly in texture, soon decaying in the weather, but good for housework. The gum is said to be used to adulterate the inferior kinds of gutta-percha; it is certainly unsaleable alone. From the seed is expressed an oil used for lamps, and when fresh, for cooking. Grows in deep bogs, where its roots are under water for five months in the year."

5. *Dichopsis obovata.*—Synonym—*Bassia obovata*, Griffiths. Remarks — This gutta-percha yielding plant is found in the Tenasserim provinces, and in Borneo.

6. *Payena puberula.*—Synonym—*Isonandra puberula*, Miquel. Remarks—Is found in Sumatra, and attains a height of 60 ft. to 80 ft.

7. *Payena dasyphylla.* — Synonym — *Isonandra dasyphylla*, Miquel. Remarks—Known under the name of Gutta Benton. and is found in Borneo and

* Jan. 18th, 1884.

Sumatra. According to Motley, it yields a second-rate gutta, and is chiefly used for purposes of mixing with finer qualities. The tree grows in dry woods, having hard, white, and heavy timber, black, hard, and smooth bark, and abundant foliage.

8. *Payena Wightii.*—Synonyms — *Ceratephorus Wightii*, Hassk.; *Isonandra polyandra*, Wight. Remarks—A Sumatran tree.

9. *Payena Leeri.*—Synonyms—*Ceratephorus Leeri*, Hassk.; *Azaola Leeri*, T. & B. Vernacular names—Balem-tjabeh, Balem tandoek, Koelan, Getah Seundek. Remarks—This tree, found in Palembeng (Sumatra), Java, and Banka, is said to yield a very fair gutta.

10. ? *Payena macrophyllus.*— Synonym — *Cacosmanthus macrophyllus*, Hasskl. Remarks—This tree, known under the names of Karel Mundieng and Getah Pertja, is found in Java, and grows to a height of 60 ft. to 70 ft.

11. *Chrysophyllum lanceolatum*, D.C. Synonyms—*C. Javanicum*, Steudel; *Nycteristition lanceolatum*, Blume. Remarks—Known as the Kilakkatang, in Java, and grows to a height of 60 to 80 ft.

12. *Chrysophyllum rhodoneuron*, Hassk.

13. *Sideroxylon nitidum*, Blume, the Kinjatoe of Banka and Njatoe of Banka.

14. *Sideroxylon attenuatum*, D.C., known as the Taroentoong and Binasie, and found in Singapore, Java, Banka, and Philippines.

15. ? *Sideroxylon chrysophyllum*, De Vriese, found Java.

16. *Bassia cuneata*, Blume, a tree of 60 to 80 ft. high, found in the Bantam district in Java.

17. *Bassia sericea*, Blume, known as Djengkot in Java.

18. *Bassia argentea*, De Vriese, growing in Java.

19. *Bassia Junghuhniana*, De Vriese, growing in Java.

20. *Mimusops Manilkara*, G. Don, the *Manilkara* of Rheede, and the *Metrosidoros Macassariensis* of Rumphius, growing in Java.

21. *Mimusops acuminata*, Blume, known as Genkot; grows in Sumatra and Java to a height of 80 to 120 feet. Remarks—Nos. 12 to 21 are all said to yield a gutta-percha which is more or less utilized; frequently, however, for mixing with better sorts. There are numerous varieties of gutta-percha which have come under my notice, to which no botanical position has been assigned. A few of these need only be mentioned here.

22. *Gutta-percha Waringen.*—Under this name a Gutta-Percha is collected on the Kapuas river in Borneo. The tree is described as being like the Waringen tree (*Ficus sp. varia*), with white wood, and grows in the hilly country, and generally in yellow clay soil.

23. *Nettu.*—Found on the south coast of Borneo, and said by Motley to yield a second-class gutta.

24. *Ploot* is found in Borneo, and yields a third-rate gutta. The tree grows in hilly districts, and its sap is brownish. The leaves and bark resemble the Champaca (*Michelia Champaca*), but the leaves are redder on the under-side. The name Ploot, or P'loot, is a Dyak term, and the only one they seem to use for gutta-percha.

25. *Gutta-percha Papua.*—This is a fourth class gutta, and is in less demand than the two preceding ones. The tree is found on low ground in Borneo.

26. *Gutta-percha Rana.*—This variety, found also in Borneo, is in very little demand, as it is of low quality; it is of a white colour when boiled.

27. *Katella.*—Borneo; used only for adulteration.

28. *Jankar.*—Same as 27.

30. *Gutta-percha Kladi.*—Same as 27.

31. *Gutta-percha Daging.*—This comes nearer in character to the Balata of commerce than any other Eastern product I have met with, and should most assuredly receive attention. "Daging" is the Malay term for "flesh," and aptly describes the toughness and gristly character of the generality of beef one meets with in the East.

32. *Gutta Muntah.*—This is unprepared gutta, "Muntah" being the Malay for "raw," or "uncooked." Hence the term is equally applicable, and, indeed, is applied to every variety of unprepared gutta-percha. Some years since, this name was known and used in the English market, but now is apparently supplanted by that of "White Borneo." It may be of the best quality of gutta-percha, or the very lowest; whichever it may be, if not boiled up quickly, it loses all its value, and becomes a mere resinous mass.

The following names and remarks on varieties of gutta-percha were kindly furnished me by Captain Lingard, who, as a trader and rajah, has had many years' experience of the question in the Brow and Boolongan districts on the east coast of Borneo:—

33. *Getah Kalapeieh Lanyut* (Brow).—Lola Lanyut, of Boolongan, is the first and best quality, and is known in the English market as Lingard's "Nina" brand. "Lanyut" means "tough."

34. *Getah Kalapeieh Mookas* (Brow).—Lola Mookas (Boolongan), is a second quality. The tree yields about 10 per cent. less than the first quality, and is more difficult to cut down. "Mookas" means "spongy."

35. *Getah Kalapeieh Kapur* (Brow).—Lola Kapur (Boolongan) is a third variety, and yields 10 per cent. less than the preceding; in the wet season even 20 per cent. less. The wood is much harder, and requires a stronger and heavier billiong to cut the tree down.

THE POPULATION OF FORMOSA.

Mr. L. C. Hopkins, in his recent report on the Island of Formosa, prepared by direction of Sir Harry Parkes, says that the population is composed of four distinct elements. The independent savages, the Pepohuans or reclaimed savages, the Hakka immigrants from the mainland and the non-Hakka

Chinese, also immigrants from the mainland. The independent savages, probably of Malay origin and divided into a large number of classes, inhabit the whole region of forest-covered mountains of Central and Eastern Formosa. Their time is spent in hunting, but they do not lead a wandering life, and do not depend entirely on the proceeds of the chase for subsistence. Those of the men who through age or infirmity are unable to hunt, till the ground with the women, raising crops of millet and other food for the rest of the tribe. The women also weave cloth of two kinds, known as "savage cloth" and "pineapple" cloth, the first a sort of grass cloth, the latter a fabric made from pineapple leaf fibre. They live together in villages, and in spite of the extreme hostility which they bear to the encroaching Chinese, are by nature civil and harmless. In the constant skirmishes between the Chinese borderers and the aborigines, the advantages are not always with the former, the savages often appearing to regain lost ground. Scattered throughout nearly the whole length of the island, and generally inhabiting the sterile and hilly lands at the foot of the great mountain ranges, where they are neither free from the covetousness of the Chinese settlers, nor always secure from attack by the untamed aborigines, are the Pepohuans, or reclaimed savages of the plain. They are the ancient pre-Chinese inhabitants of the flat lands, from which they have been gradually driven by the Hakka and other Chinese settlers, until they are now being pushed on to the very verge of the savage territory. Large and well-built physically, they are mild and inoffensive in disposition, and appear to have received some teaching from the Dutch in the seventeenth century. They have been ousted from their lands, and pressed further east, by the Chinese, principally by means of foreclosed mortgages. The Chinese are always ready to lend on the security of land, and the Pepohuans, who are a careless race, are equally ready to borrow. In this way, most of the land has changed hands. On the east coast, commencing about twenty-five miles south of Kelung, and extending some fourteen miles further to Suao Bay, lies a fertile and beautiful plain or valley, called Kapsulan. Bounded inland by a semi-circle of mountains, the valley is one vast rice-field, studded with Pepohuan villages, and it is stated that Christianity is spreading rapidly among this population. The Hakkas, or Chinese immigrants, form a strongly marked and important feature of the Formosan population. It is they who carry on the barter trade with the savages, whom they supply with guns, powder, and knives, chiefly of their own manufacture, receiving in exchange, skins, hardwood, camphor, and native cloth. They are the camphor manufacturers also, and have many thriving villages on the border marches, where they live independent of the Chinese administration. Up to 1874, many of the large Hakka villages would not even allow an official to enter their fortified precincts. The rule of the Chinese magistrate reduced itself to the industrious and orderly population of the western plains, official aid being sought for at times only in serious cases of lawsuits, criminal cases being settled according to lynch law. These independent village communities carried on the barter trade with the savages, in which no outsiders could participate; even official communication with the savages, in most instances, was only carried on through the independent savages and Pepohuans. Some change has taken place since that time, and aborigines in small numbers may now be met with at the capital of the island, and at other large places.

THE ELECTRIC LIGHTING OF TRAINS IN GERMANY.

The railway administration at Frankfort-on-the-Maine have recently repeated some experiments on the lighting of trains by electricity, which are said to have been attended by most satisfactory results. The experimental train was composed of a first, second, and third class carriage, and a luggage-van, which contained a special compartment for the dynamo and accumulators. The dynamo was of the Moehring type, and was driven by a suitable arrangement of pulleys and belts from the axle of the wheels of the van, and at a velocity of 700 revolutions per minute, when the train was running at a speed of 18 to 42 miles an hour. When the train is running at full speed, the lamps remain in circuit whilst the accumulators are being charged, but when the speed is less than 18 miles per hour, then the lamps are thrown out of circuit, and the current is supplied direct from the accumulators, a specially constructed automatic commutator regulating its intensity. During the day the lamps are thrown out of circuit, and the 26 accumulators are charged by the dynamo when the train is in motion. This installation weighs about 12 cwt., and costs £125.

The train was lighted by twelve incandescent lamps, of which two were in the luggage-van, two in the third-class carriage, four in the first, and the remaining four in the second-class carriage. The cost of fitting each carriage varies from £3 4s to £4. It may be observed that this installation would have been sufficient for lighting two other carriages.

These experiments clearly demonstrate the practicability of lighting trains by electricity, the light being perfectly steady during the journey, and at variable speed, and even during stoppages at stations; only at starting a slight oscillation was perceptible. As all is regulated automatically, no attendant is required, except at starting. The experiments were continued for six weeks, at the end of which time everything was found in perfect order. The cost of lighting is estimated at ten centimes per lamp per hour.

GREEK CURRANT CROP OF 1884.

According to Consul Wood's report on the trade of Patras, the prospect of an abundant crop of currants was very good up to the month of August, when the gathering commences, and the currants are mostly spread on the ground, with the exception of a small proportion dried in wooden trays. On the 12th August, slight rain occurred, but on the 16th and 23rd August, the storms were most violent. Torrents of rain fell, accompanied by thunder and lightning, so that about 10,000 tons of currants were lost. The damage to the fruit saved was considerable, as the currant is a very delicate description of grape, and the expense of turning and removing the bunches to drier ground was enormous.

The shipments to the end of the year from the various places of growth, of the crop of 1884, compared with those of 1883, are as follows:—

	1884. Tons.	1883. Tons.
To United Kingdom	59,629	52,099
United States	8,968	8,753
Canada	950	1,073
France	16,282	13,983
North of Europe	4,589	8,638
Trieste	3,247	1,579
Russia	66	88
Australia	796	458
	94,527	86,671

The stock of currants unsold or held for shipment in Greece and the Islands reaches—

	Tons.
Calamata and Nisi	4,200
Provincial	4,500
Pirgos and Gastouni	10,000
Patras and Vostizza	2,223
Zante and Cephalonia	4,550
	25,473

Shipping was abundant during the season, and the average rate of freight was—

	Per Ton.
To London	17s. 6d. and 10 per cent.
Liverpool	20s. "
New York	20s. to 25s. "
Marseilles	16f. and 5 per cent.
Rouen	30f. "

Some competition took place against British steamers by vessels under the Norwegian flag, and 17 steamers of that nationality loaded currants. Goods to the United States were carried by British steamers.

Correspondence.

TREATMENT OF SEWAGE.

Dr. Meymott Tidy and Professor Dewar have completed their researches at Aylesbury for the purpose of determining the efficiency of the A.B.C. process in the treatment of sewage; and I send a brief report of their investigations, as really representing the every-day working of that system. The experiments were continued systematically throughout three distinct periods of twenty-four hours, the process being uniformly worked during each period; their attention being also specially directed to the relative proportions of the precipitating agents and sewage matter in the resultant sludge.

Having regard to the remarkable evidence given in the Lower Thames Valley Drainage Inquiry, before a Committee of the House of Commons in July, 1884, as to the efficacy of certain reagents in removing from sewage organic matter, whether in suspension or solution, these confirmatory conclusions of two most experienced chemists are both opportune and encouraging; especially to those who had the courage of their opinions through good report and evil report.

According to the summary contained in the report, the following facts and generalisations seem to be established:—

With Respect to Suspended Matters.

1. The effluent was practically clear—containing throughout the whole series of observations an average quantity of one grain of suspended matter per gallon.

2. As the quantity of suspended matter in the raw sewage increased, the precipitation appeared to be more complete.

3. Notwithstanding the varying nature and concentration of the raw material treated, the process is capable of producing an effluent of remarkable uniformity, having regard to the total quantity of organic matter removed.

With Respect to Organic Matter in Solution.

The proportion precipitated in No. 2 series of experiments was 61·4 per cent. In No. 3, it was 57 per cent.; and of the residue left in the effluent, at least two-thirds was found to be non-albumenous, and, therefore, of a nature less liable to putrefaction and other changes. In other words, the process will clarify sewage, and purify it so far as to deprive it of its more noxious and putrescible properties.

Throughout the whole series of researches there was no nuisance; and the sewage was completely and immediately deodorised, nothing offensive from the beginning to the end of the process being detected in the surrounding air.

Resultant Sludge.

The per-centage of combined nitrogen in the manure is remarkably constant, and amounts to an average of 3 per cent. of available ammonia. Of phosphoric acid, an average of 5 per cent. was found in the samples of manure taken, reckoned as tricalcic phosphate of lime.

Finally, both gentlemen wisely abstain from any arbitrary determination of the value of the manure known as Native Guano, being "strongly of opinion that this must be judged rather by the practical results of the agriculturist than by presumed theoretical values based on analytical data, and the price of ingredients not necessarily in the same physical or chemical condition."

Farmers, after all, will judge by results in a series of seasons wet and dry; whilst sanitary authorities will have in this exhaustive report the means of solving many doubts, which have hampered them too long in the work of sewage purification.

C. N. Cresswell.

1 Hare-court, Temple,
May 19th, 1885.

General Notes.

Canal Conference.—It has been arranged to hold an International Congress on Inland Navigation, at Brussels, between the 25th and 30th May, which will be under the patronage of the Belgian Government. Information as to the subjects to be discussed, and the general arrangements, can be obtained from M. Louis Cavens, 75, Rue de la Regence, Bruxelles.

Tea in Italy.—The French Consul at Naples gives an account, in a late report, of the attempts which have been made to acclimatise the tea plant in Italy. The first is said to have been made by the English during their occupation of Sicily at the beginning of the century, when the plant reached a height of 6 ft. in the open air. There is no proof, however, that any crop was obtained, and no further attempt seems to have been made until 1871, when some seeds were sown at Caltanisetta, which is in much the same latitude as Jamascioro (in Japan), from which place they were brought. The seeds never sprouted, and a fresh trial made in 1875 with another variety, the *thea sinensis*, also proved a failure. The Government, however, which had taken up the question, was not discouraged, and, after weighing the various opinions which it had elicited, made several fresh plantations of *thea sinensis* in the zone comprised between Florence, Naples, and Sicily. These plantations also came to nothing, but Signor d'Amico, a landed proprietor in the province of Messina, was able to exhibit, at the Agricultural Show held at Messina, in 1882, more than a hundred plants of the *thea sinensis*, three years old, which had been grown in the open. Prof. Beccari, too, who has been to India for the purpose of investigating the growth of tea, is of opinion that there is no reason why it should not succeed in Italy if the plants and the seed are brought from a climate similar to that of the Peninsula, for the fact of its growing in the open air along the Riviera, upon the shores of Lago Maggiore, and at Florence, proves that it is to a certain extent a hardy plant. If it has not been more generally grown in Italy hitherto, this is, Professor Beccari thinks, because the mode of cultivation has been wrong. The Italians have thought that the plant wanted shade, whereas in India and China it is grown in very open gronnd and upon a soil which contains a large proportion of sand and oxide of iron. He recommends, therefore, that it should be planted in land not too dry, and in a soil preserving enough moisture to aliment the plants, such as the ollve-growing fields of the Riviera, the Maremma, and Southern Italy, and that the plants should be brought from the coldest provinces of Japan. The Italian Minister of Agriculture has determined to act upon Professor Beccari's report, and has already sent a large order to Japan, besides buying a number of plants from a landed proprietor at Pallanza, in the province of Novara, who has met with a fair amount of success in his experiments.

MEETINGS FOR THE ENSUING WEEK.

Tuesday, May 26.. Royal Institution, Albemarle-street, W., 3 p.m. Professor Gamgee, "Digestion and Nutrition." (Lecture XI.)
Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Wednesday, May 27...Geological, Burlington-house, W., 8 p.m. 1. Prof. T. G. Bonney, "The so-called Diorite of Little Knott, with further remarks on the occurence of Picrites in Wales." 2. Mr. W. H. Penning, "Sketches of South-African Geology.—No. 2. A Sketch of the Gold Fields of the Transvaal, South Africa." 3. Dr. Charles Richards, "Some Erratics in the Boulder-clay of Cheshire, &c., and the Conditions of Climate they denote."
Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

Thursday, May 28...Royal Institution, Albemarle-street, W., 8 p.m. Prof. C. Meymott Tidy, "Poisons." (Lecture II.)
Telegraph-Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. 1. Mr. B. J. Farquharson, "Ship Lighting by Glow-lamps, embodying results of trial for economy in H.M.S. *Colossus*." 2. Mr. J. N. Shoolbred, "Electric Lighting at the Forth-bridge Works."

Friday, May 29...United Service Institution, Whitehall-yard, S.W., 3 p.m. Lieut. A. W. Chisholm-Batten, "Electricity as Applied to Naval Purposes."
Royal Institution, Albemarle street, W., 8 p.m. Weekly Meeting. 9 p.m. Mr. J. J. Coleman and Prof. J. G. McKendrick, "Mechanical Pro duction of Cold, and Effects of Cold on Microphytes."
Engineering Society, University College, W.C., 8 p.m. Mr. R. F. Hayward, "Boiler Explosions."

Saturday, May 30...Royal Institution, Albemarle-street, W., 3 p.m. Rev. C. Taylor, "The Teaching of the Twelve Apostles"—an Ancient Document—with Illustrations from the Talmud.

Journal of the Society of Arts.

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FRIDAY, MAY 29, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by the kind permission of the Executive Council of the International Inventions Exhibition, in the Exhibition-buildings, South Kensington, on Friday, the 3rd of July next.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. In addition to this, cards will be sold to members of the Society, or to persons introduced by a member, at the following prices:—Until the 20th of June, 5s. each; from that date until the 30th of June, 7s. 6d.; on the 1st, 2nd, and 3rd of July, 10s. each.

The Council, however, reserve the right of stopping the sale of tickets or of raising the price, if it is found necessary, in order to restrict the number of visitors within reasonable limits.

Tickets will only be supplied to persons presenting members' vouchers, (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter, a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase. It will greatly facilitate the arrangements if members requiring additional tickets will apply for them at as early a date as convenient. The members' invitations will be issued early in June. Visitors' tickets can be purchased from the present date.

There will be no admission to the Exhibition on this evening except by special ticket, and no tickets can be purchased at the Exhibition.

Further particulars as to the arrangements will be announced in future numbers of the *Journal.*

INTERNATIONAL INVENTIONS EXHIBITION SEASON TICKETS.

The Executive Council of the International Inventions Exhibition have consented to allow Members of the Society of Arts the privilege of purchasing Season Tickets for the Exhibition at half-price (10s. 6d.) Any member desiring to avail himself of the privilege can obtain a ticket by applying to the Secretary, and remitting the price, 10s. 6d. Each member will only be allowed the privilege of purchasing a single ticket on these terms, which will be a personal admission, not transferable. It will be understood that all applications must be accompanied by the above-named remittance, and that tickets at the reduced rate can only be obtained from the Secretary of the Society.

Proceedings of the Society.

INDIAN SECTION.

Friday, May 15, 1885; The Hon. Edward Stanhope, M.P., in the chair.

The paper read was—

THE GOLDEN ROAD TO SOUTH-WESTERN CHINA.

By Professor R. K. Douglas.

The subject on which I have the honour to address you this evening is one of vital importance to Englishmen, from a commercial as well as from a political point of view. It affects our interests in one of the potentially richest markets in the world, and it affects our position as an imperial Power in the East. I could have wished that so important a question had been placed in the hands of someone more entitled to a hearing as being better acquainted with the immediate localities than I am; but having been invited by my friend, the Secretary of the Section, to appear before you this evening, I did not hesitate to take the opportunity thus afforded me of urging upon the members of this Society the great importance of securing the Golden Road to Western China as an open highway for the commerce of the world.

It cannot be necessary, at this time of day, to enlarge upon the commercial wealth of the provinces of South-Western China. The repeated attempts which have been made from all sides, north, east, south, and west, to open communication with that coveted region, is enough to testify to the opinion generally held as to its riches. From the side of Burmah, expedition after expedition has striven to open a practicable trade route over the mountain ranges which separate Bhamo from Tali Foo; adventurous Russians have tried to create a short cut through the province of Kansuh into Sze-chuen and Yunnan; English merchants at Shanghai, not being contented with the trade of Eastern China, have attempted to find a possible channel over the rapids which disturb the course of the upper Yang-tsze-kiang; Mr. Colquhoun, in pursuit of the same object, has laboriously travelled westward from Canton, by the dangerous waters of the Se-kiang; and Frenchmen, possessed with a desire to effect a diplomatic victory, have done their utmost, against almost insuperable physical difficulties, to force their way into Yunnan, first by the Mekong, and later by the Red River of Tung-king. All these routes have been tried, and not one has fully answered the expectations of its advocates. No doubt there has existed for many centuries a trade route from Bhamo to Western China by way of Têng-yueh and Tali, but it is only necessary for me to quote the remarks of that distinguished traveller, Mr. Baber, on the difficulties of this road, to account for the hesitation with which the proposal to open it to international commerce has generally been received:—

"The trade route from Yunnanfu to Têng-yueh is the worst possible route with the least possible trade. It is actually dangerous to a cautious pedestrian. . . . By an improved system of paving, and a better selection of gradients, the route might be made convenient enough for carriage by mules or coolies, but it seems hopeless to think of making it practicable for wheel carriages. The valleys, or rather abysses, of the Salwen and Mekong must long remain insuperable difficulties, not to mention many other obstacles. I do not mean," he adds, "that it would be impossible to construct a railway. A high authority has informed me that if shareholders will provide money, they will always find an engineer to spend it. By piercing half-a-dozen Mont Cenis tunnels and erecting a few Menai bridges, the road from Burmah to Yunnanfu could doubtless be much improved."

Of the Russian venture nothing more need be said than that it has not been repeated. Russians never yield to political impediments when dealing with Oriental states, and it may safely be inferred, therefore, that they never re-appeared in Sze-chuen for the simple reason that they found the physical difficulties in the way formed prohibitory barriers to trade. In the same way the French on the Mekong, and the Shanghai merchants and Mr. Colquhoun on the Yang-tsze-kiang and Se-kiang, had to yield to the obstacles opposed by nature to their explorations. The accounts given by M. Dupuis of his voyage up the Red River from Hanoi to Manhao in Yunnan is sufficiently discouraging to damp the ardour of even French adventurers, who, even if they succeeded in reaching that goal, would find themselves—as Mr. Baber has epigrammatically expressed it—"planted in an opium field." The entire distance from Fort Dupuis on the Red River to Manhao, a distance in a straight line of about 105 miles, is beset with rapids which make navigation impossible for steamers, and difficult even for native boats of the lightest draught. By a process of exhaustion, therefore, we are driven to look towards the south as the quarter from which South-Western China may be reached, and from this direction two routes present themselves. One of these, which has been suggested by Mr. Gordon, late superintendent of works in British Burmah, would connect Mandalay and Thein-ny with the principal cities of Yunnan, by way of the valley of the Nan-ting River. This route possesses many advantages, and I trust that we may hear something of it from Mr. Gordon. The other, namely, that known as the Golden Route, proceeds from Maulmein and Bangkok, up the valleys of the Menam and Meping as far as Zimmé or Lakhon, and from thence onwards through the Shan states of Kiang-tung and Kiang-hung to Sze-mao in Yunnan.

A study of the map is enough to show at first sight that the physical features of the country are in favour of this line of road. The greater part of Yunnan forms "an uneven plateau, in which the main ranges tend north and south." These ranges are divided by fertile valleys, through which run rivers varying in size from the Salween—which is one of the great rivers of the world—and the Mekong—which is scarcely inferior to it—to small streams and rivulets. Passing southwards, beyond the frontiers of China, the ranges take a slightly westerly direction, and form a series of barriers between Burmah and the valley of the Menam. The mountains themselves are

barren and comparatively unprofitable, except for mining purposes, but the intervening spaces are teeming with populous villages, towns, and cities, and yield large and profitable crops in return for the labour bestowed upon them. The valleys are, therefore, the desired districts, and it is obviously easier to reach them by ascending them than by attempting to cross the mountain ranges into them, always supposing that the detour to be made is not long enough to present counterbalancing disadvantages. This appears to be beyond the reach of controversy. But next comes the question how are the entrances to the valleys to be reached, and this is the question which Mr. Colquhoun and Mr. Holt Hallett have, in one direction, effectually solved. Solved, however, is not the right word, for the native traders solved the question many centuries ago, and I should rather say, therefore, that Messrs. Colquhoun and Holt Hallett, treading in the footsteps of McLeod and others, have brought to light the solution. The Golden Road has commended itself to native traders as being the easiest and the most profitable of the southern trade routes, since not only is it free from serious physical obstacles, but it traverses commercially rich districts, which support a series of markets along the whole line of road, from the Yunnan frontier to the sea at Maulmein and Bangkok. The distance which separates Sze-mao, or Esmok, the border town of China, from Bangkok, is about 878 miles, 190 of which pass through the Chinese Shan country, and the remainder traverse Siamese territory.

An ancient topographical history of the Province of Yunnan sketches this route in the following terms :—

"The lower route for tribute elephants leads from Chin-tung to Ch'ên-yuan-fu, one day's journey, and then in two days enters the district of Ch'ê-li. Two days more brings the traveller to P'u-erh, which is subject to Ch'ê-li. This region produces tea, and contains a lofty and beautiful hill called Ming-Kuang, on which a chief of Ch'ê-li resides. In two days more a great river is reached, making a bend round some 300 miles of country in which elephants breed. . . . Travelling from Ch'ê-li, eight days' journey to the south-west, one reaches Pa-pe-se-fu (eight hundred wives, the modern Muang Yong), a country abounding in temples and pagodas. Every village possesses a temple, every temple a pagoda; there are 10,000 villages and 10,000 pagodas. . . . One month's journey to the south-west lies Lao-chua (the Shan country of Chandaputri). . . Fifteen or sixteen days westward brings one to the shore of the western sea in Pegu."*

On leaving the Chinese frontier, the Ch'ê-li of the above extract, the route southwards lies through the Shan State of Kiang-hung, and though the road to the capital of this State, which bears the same name, is hilly, it is easily traversed by caravans in five days, being at the rate of about fifteen miles a day. Of the capabilities of this part of the route, M. Garnier, who travelled along it in 1867, speaks in favourable terms, and the sculptured remains met with *en route* bear ample testimony to the former importance of the district, and to the wealth and cultivation of the natives.

Like most modern Oriental cities, the town of Kiang-hung is in outward appearance poor and contemptible. The inhabitants, who bear in their features the evidence of admixture of Chinese and Shan blood, are fair in complexion, of middle height, and possess that instinct for trade which seems to be the heritage of the two races from which they have sprung. A bazaar is held in the market every fifth day, at which the native products, such as silver, iron, salt, tea, cattle, cotton, medicines, &c., are exchanged for English piece goods, needles and cutlery from Rangoon, and wax, coloured paper, and a number of miscellaneous articles of commerce from China. Much of the road lies through the valley of the Nam-Yot river, which is richly cultivated, and abounds in prosperous-looking villages. The inhabitants of this favoured region bear unmistakeable evidence of the mineral wealth of the district in the number of trinkets that adorn their persons, the women especially being decked out with silver ornaments in a way which reminded M. Garnier of the adornments of the women of Switzerland and of Bretagne. On approaching the walls of the city of Kiang-hung from the north, the Mekong, which here makes a bend eastward, has to be crossed, and though now a ferry-boat takes the traveller and his goods to the other side, there would be no difficulty in the way of constructing a bridge over the stream. The city of Kiang-hung stands 2,000 feet above the sea, on the western face of a range of hills, which run, in common with all the other ranges, north and south. It is within this State that the celebrated tea which, by a misnomer, derives its name from the prefecture

* Baber's notes on route of Mr. Grosvenor's mission through Western Yunnan.

of Pu-erh in Yunnan, is grown. The peculiar delicacy of its flavour causes it to be highly prized, and, according to McLeod, 560 mule loads are annually paid as a tax to China. Twenty-five of these loads, consisting of the most tender shoots, are forwarded to Peking for the special use of the Emperor. But though freely drunk in the neighbourhood in which it is grown, the cost of carriage inland is so great that exportation to Europe becomes a commercial impossibility.

Starting southwards from Kiang-hung, two roads present themselves; one following the course of the Mekong as far as Kiang-tsen, and from thence in a south-westerly course to Kiang-hai; the other, which is the more approved native road, owing to the floods which occasionally inundate the valley of the Mekong, making a bow westward to Kiang-tung, and so round to the same point. From the railway engineers' point of view, the route by the Mekong is the one which should be preferred; but if we are to keep strictly to the Golden Road, we must bid adieu to the engineers, and follow in the train of heavily-laden mules, oxen, and elephants to Kiang-tung, distance 132 miles. The first part of the road crosses low hills, on which may be met troops of Chinese porters conveying cloth and cotton to China, and hawking their native wares from village to village.

These hills are for the most part covered with a thick jungle, varied by occasional spaces cleared for cultivation by the Lawas, a tribe possessed of industrious habits, but otherwise standing low in the scale of civilisation. In referring to these people, Mr. Colquhoun says, "It was amusing to find the dread in which the Lawas are held by both Burmese and Siamese. This is due to the fear of being bitten by them and dying of the bite. They are called by their Burmese neighbours the 'man-bears.' A singular custom obtains amongst these people, which may perhaps account partly for this superstition; on a certain night in the year the youths and maidens meet together for the purpose of pairing. Unacceptable youths are said to be bitten severely if they make advances to the ladies; while, on the contrary, the more favoured swains are received with blandishments and kisses, if the caresses in this part of the East can be called by such a name. Burmese travellers, hearing of this custom, are reported on one occasion to have attempted to take unfair advantage of it. The treatment they received from the Lawa damsels is said to have taught them a lesson which has given good grounds on which to base the tradition." The remainder of the route to Kiang-tung is easy and pleasant to travel, for the most part lying through rich and well cultivated valleys with numerous busy towns and villages, the commercial activity of which is evidenced by the number of Chinese coolies passing from place to place, as the requirements of trade and their personal self-interest direct.

The town of Kiang-tung is clean and well built, and consists of about 300 houses, according to Mr. Colquhoun, and double that number according to Captain McLeod. It is a great thoroughfare for the Chinese, who visit it in their thousands, and spread themselves from it over the neighbouring districts. Most of the resident merchants also are Chinese, who drive a considerable trade by exporting the cotton and tea of the district, in exchange for piece and woollen goods, carpets, thick cotton cloths, fur jackets, and salt. The presence of resident Chinamen here, as elsewhere, may be taken as an infallible proof of the existence of a profitable trade. Chinamen are, in Indo-China, the natural pioneers of commerce, and just as we are accustomed to associate the idea of well-filled godowns with the sight of the British consular flag at treaty ports in the east, so the presence in a town of burly Chinese traders is a sure indication that they have a good and profitable reason for being there.

The road from Kiang-tung to Zimmé presents no difficulties, either to the traveller or the merchant. For a considerable distance it lies through "a fertile and well-cultivated country, irrigated by canals, and having numerous villages scattered over it." Tea grows wild in this part of the country, and the Lawa owners, when not biting their enemies, devote themelves to the production of tobacco, sugar-cane, cotton, safflower, &c., from the surface of the soil, and to the manufacture of implements from the iron which they find in abundance beneath it.

Zimmé, sometimes written Kiang-mai and Chieng-mai, is a town of considerable importance, and stands in the valley of the Meping river. It is surrounded by two lines of fortification, within the inner of which resides the Tsobua, in company with the owners of some 900 houses. In reckoning the population on this basis, it is necessary to remember that, as Mr. Colquhoun has pointed out, a Shan household often consists of forty or fifty persons. Within the outer lines are

as many more houses, and the total population, irrespective of that of the suburbs and neighbouring villages, is about 25,000. A market is held along the main streets every morning, the local produce, such as vegetables and edibles generally, being sold by women seated at the side of the street, while behind them sit Burmese and Chinese traders in their shops, prepared to deal in the weightier matters of "cotton goods, calico prints, brass and wooden trays, and a varied assortment of Burmese and Shan lacquer ware." Besides these traders, travelling merchants from Yunnan are constantly to be met with, who, in exchange for the wax, opium, "scissors and ironware of various sorts, brass bells, skin jackets, silk, cloth, and straw hats," they bring with them, carry away "cotton, ivory, rhinoceros and deer horns, dried shrimps, birds' feathers, &c." In the neighbourhood teak forests abound, and large herds of cattle and elephants find support on the uncultivated lands. At present, to quote Carl Bock, "only about a tenth of the country is under cultivation, not counting the many mineral deposits, which are completely neglected. Gold in small quantities is found in the streamlets which intersect the district, and I have every reason to believe that these streams pass through deposits of quartz. I had an opportunity of visiting excellent iron and lead mines in the neighbourhood of the town. To the north there are several petroleum wells. The country possesses great resources, and I feel positive that if a railway from Bangkok to Raheng were constructed, the road would soon be continued to Zimmé, a distance of only about 180 miles. . . . . Those who have not visited the country cannot, in fact, form an idea of its commercial importance, and of the great future which it may have. The principal revenue of the town is derived from the large forests of teak westward of the town, which are worked by Burmans. Another source of revenue, though of less importance, is the export of lac, of which, during the last year, no less than 14,000 piculs, or 1,862,000 lbs., were sent to Bangkok. . . . . Its favourable position between Siam and Burmah, thereby controlling the trade between these two countries, gives it a real commercial and political importance."

So far as Zimmé, the Chinese and other traders find no difficulty in travelling. The road is rough in some parts and steep in others, but the mode of travelling is the one they are accustomed to, and the obstacles are not such as seriously to impede them. Beyond Zimmé, however, the River Meping forms the ordinary mode of transport, and this exchange of conveyance, added to the difficulties and delays of the river route, acts as a bar to the progress southwards of the merchants. From this point, therefore, the trade becomes almost entirely local, but so rich and productive is the country, that there is still enough traffic to make the river a busy highway. Below Zimmé the river is "lined with villages, and with the never ending paddy fields, and betel nut and cocoa-palm plantations," while in the second line are large cattle farms and elephant grounds. One hundred and eighty miles down the river, Raheng, a considerable town, is reached. This place is, according to Carl Bock, the most important town in Upper Siam, and though, as a city, its appearance is mean, it is the centre of a considerable trade in teak, sapan wood, resin, horns, skins, beeswax, &c. Speaking of the best means of utilising these and other products of the district, Carl Bock writes:—

"A railway from Bangkok to this point would offer no engineering difficulties. The whole country is one vast plain, presenting fewer obstacles than even the American prairie for the construction of a railway, which would have the advantage that it would pass through a district thickly studded with villages, each of which would bring its quota to the traffic. The river is the only existing highway . . . . but it is not navigable for steamers above Pakuan Po, and the existence of numerous sandbanks render the navigation dangerous and uncertain. The journey by boat from Bangkok to Raheng occupies, at the very best of times, twelve days, while the natives, as a rule, take much longer to do the voyage. The journey down stream takes as long, and sometimes longer. (I may remark that Mr. Hallett considers that under any but the most favourable circumstances these estimates are considerably under the mark). . . . A railway, on the other hand, would enable the distance—about 300 miles—to be accomplished, at the rate of only twelve miles an hour, in fifteen hours. Even Oriental deliberation could hardly prevent a traveller from breakfasting at Bangkok at 6 a.m., and dining at Raheng at 8 p.m."

The route thus indicated includes a large portion of the Golden Road—that is, the road from Yunnan to the sea at Maulmein and Rangoon—and if a railway should be made from Bangkok northwards in connection with it, there can be no doubt that the local traffic would be so developed, and the through traffic so encouraged, that there would be an abundance of lucrative work to be done on the

line. For the purposes of a European trade, it is obvious that the fact of Bangkok being situated to the east of the Malay peninsula militates against its suitability as a port of egress and ingress, and the attention of all those interested in the subject has, therefore, been drawn to the advantages of connecting Maulmein and Rangoon with the Siamese system. Two or three routes have been suggested for this connecting piece of line; the one advocated by Mr. Colquhoun would leave the Zimmé and Bangkok line at Muang Haut, and crossing the Baw plateau, would descend on the Burmese side to Maulmein, with a branch joining the Toungoo and Rangoon railway; while that proposed by Mr. Holt Hallett would start from Raheng, and would reach the same destination by way of Myawaddi, a town on the British side of the Thoung-yeen river. The distance to be travelled by the last route would be only 125 miles, and the highest point to be crossed would be 2,237 feet above the sea level. As an easy gradient would without difficulty be constructed over this part of the country, the obstacles present no serious difficulties in the way of the scheme. Experience in America has shown what can be done in the way of crossing mountain ranges, to which this altitude is but a trifle, and when the work is undertaken, it may be worth while to consider whether the American system of laying mountain railways might not be adopted with advantage on the more hilly portions of the line.

So far as the physical features of the country from Bangkok to Sze-mao and across to Maulmein and Rangoon are concerned, there is nothing to prevent the construction of a railway. But it must always be borne in mind that in any such line or lines there are two interests to serve, the first being the through traffic, and the second the local traffic.

In considering the through traffic, we must look to some place on the Yang-tsze-kiang as the objective point to be reached. Anything short of this would fail to meet the requirements of more than an extended local traffic, and if our ambition soars beyond this, we must not be content until goods can be loaded on to railway trucks at Sü-chow Foo in Sze-chuen, or some such place, on the Yang-tsze and conveyed through to Maulmein or Rangoon. I name Sü-chow Foo because it was the point struck by M. Garnier with the French expedition, which entered Yunnan at Sze-mao, and because the river is navigable thus far, though not by steamers. We have the evidence of M. Garnier that the route he traversed presents no serious physical obstacles, and that even at the time when he travelled along it, while the country was still suffering from the effects of a more than usually destructive war, there was a considerable trade carried on between the cities he passed through. Both in point of mileage and in point of expense, the advantages of this route to Western China over the orthodox way by Shanghai are so great, that it is only necessary to state them.

The distance, *viâ* Shanghai and the river, is (I quote from Capt. Sprye's report):—

From England, *viâ* the Suez Canal, to Shanghai	10,488 miles.
From Shanghai, up the Yang-tsze, to the West of China (Sü-chow Foo)	1,750 ,,
Total	12,238 ,,

Viâ Rangoon and rail:—

From England, *viâ* the Suez Canal, to Rangoon	7,830 miles.
From Rangoon to Sü-chow Foo on to Yang-tsze	1,200 ,,
Total	9,030 ,,

Difference in favour of Rangoon and direct rail 3,208 miles.

If the line from Sü-chow Foo were extended some 400 miles, the port of I-chang, on the Yang-tsze, might be reached, and thus the railway would be brought into direct steam communication with Shanghai. Speaking of I-chang, Capt. Blakeston says:—

"Eleven hundred statute miles up the Yang-tsze kiang, at a point where, after crossing the fertile province of Sze-chuen and breaking through a rugged mountainous region that now emerges into the Great Plain of Hoopeh, the situation of I-chang is one of the most important on the great highway of Middle China. Easily accessible to large steamers at all seasons of the year, and at the portal, as it were, of the more unmanageable upper waters, I-chang, when European traders push their commerce more into the western country, will probably become a great place of business as a port of transhipment."

At the present time, the charges on the transport of goods from Hankow, on the Yang-tsze, to Talifoo, in Yunnan, are, by the cheapest route, 69 per cent., including interest, as against $28\frac{1}{2}$ per cent. from Sze-mao. With a railway, these last might be reduced to about a halfpenny per ton per mile. On this

one piece of the route, therefore, a large saving would be effected, and not only would the difference between freight charges from England to Sze-mao compared with those from England to Hankow, *viâ* Shanghai, be very appreciable, but the saving in time would be immense.

The great object to be kept steadily in view, therefore, is the construction of a line from Maulmein to the Yang-tsze. The advantages of such a railway to all concerned are patent to everybody. To European merchants new and rich markets would be opened, an immense impetus would be given to the trade and industry of Siam, and the wealth of Yunnan and Sze-chuen, which now lies locked up, would find an easy and profitable outlet. It may be said that the idea of such a railway is little better than a dream, and that in suggesting it "I run before my horse to market." And it must be confessed that at the present moment there does not appear to be any immediate prospects of being able to carry it out. There has been in China, until lately, a decided opposition to the introduction of railways. But this opposition is now disappearing under the influence of advancing knowledge, and it is by no means impossible that before long the Imperial sanction might be gained for a railway such as I speak of, provided always that it can be proved to be a want. The political events of the last few years have shown the Chinese which nations are to be feared as neighbours, and which may with safety be treated as friends. Under the fortunate influence of a succession of able and conciliatory British plenipotentiaries at Peking, from Sir Frederick Bruce to Sir Thomas Wade and Sir Harry Parkes (whose untimely death we are now lamenting), the Chinese have learnt to regard England as a friendly, just, and non-aggressive power. This frame of mind was, I have reason to believe, evidenced in the exchange of views between the two Governments on the subject of the recent disturbances on the Burmo-Chinese frontier, when it became plain that the Chinese, far from objecting to our possessing a frontier conterminous with theirs, would welcome us as neighbours. Their opposition, therefore, to a railway as far as the Yang-tsze would likely to be less if it was made under English auspices than if promoted by any other Power. Another reason why this work belongs with appropriateness to us, is that already our Burmese fellow-subjects have a large stake in the country. The teak forests are worked almost entirely by them, and so preponderating is their general commercial influence, that the rupee is the only current coin between Raheng and the Chinese frontier.

The construction of this line must, in any circumstance, be a question of time, and for the immediate present, therefore, it is necessary to consider some such scheme as that proposed by Messrs. Colquhoun and Hallett. This is that—the consent of the King of Siam having been obtained to the construction of a railway to the northern frontier of Siam in the direction of Kiang-hung and Sze-mao—the work should be at once undertaken. When circumstances render the best thing to be done impracticable, it is wise to be content with what is possible, and failing the through line, therefore, the shortened railway to Kiang-tsen should be the object to be attained. And in connection with this, we have to consider how far it is likely to be a paying line. I have already indicated the nature of the local traffic existing at the present time in Northern Siam. Every traveller who has visited the country has told us of the trains of laden mules, oxen, and porters which are constantly to be met with on the roads. We hear of populous and busy towns, well-to-do villages, and well-stocked markets. We find that the Shans, preserving the heritage of commercial ability possessed by their ancestors in Western China, are active and prosperous traders; that the soil of the country is fertile, and that it possesses in its teak forests and subterannean wealth natural advantages of no mean order. Further south, in the valley of the Menam, we find a soil as rich as any to be met with northwards, and the cultivation, under the industrious hands of Chinese labourers, carried to perfection. If this is the state of things in the dry tree of native indifference to trade, what might not be expected in the green tree of an active and enlightened commercial system. Trade, it must be remembered, is a growth, not a manufacture, and it is only after every opportunity has for a considerable time been given to commerce, that the full capabilities of a country and people can be realised.

There is, however, every reason to believe that in a very short time a line from Kiang-tsen to Bangkok, with a branch to Maulmein and Rangoon, would become remunerative. And the presumptive evidence of this is to be found in the success which has attended the railways from Rangoon to Prome and Toungoo, in British Burmah. Although only 170 miles long, the first of these is the most profitable of

the Indian Government railways, notwithstanding the fact that it has to compete along its entire length with the steamers of the Irrawadi Flotilla Company. No such competition could contend for the trade in the valley of the Menam, and the railway would have the additional advantage over the Burmese lines of extending to far more populous towns than either Prome or Toungoo. Prome is said to contain 28,813 inhabitants, and Toungoo 17,199; whereas the populations of Rabeng and Zimmé, together with their neighbouring villages, are set down—doubtless with some exaggeration—as being 45,000 and 100,000 respectively, and that of Kiang-tsen, the proposed terminus, as rapidly springing up amid the remains of a recently ruined city, under the influence of peace and of reviving trade. The impetus which would be given to the commercial activity of the people, by opening up ready means of communication, would be enormous, and on this point, also, we can draw hopeful indications from somewhat analogous conditions in British Burmah. Mr. Gordon has been kind enough to give me a comparative statement of the area under cultivation in the province of Prome in the years 1876-77 and 1880-81. At the first date—that is to say, at the opening of the railway to Prome—there were under cultivation 155,966 acres, and four years later this number had increased to 193,328. This is but an example of the extraordinary way in which trade in the East increases by leaps and bounds, so soon as the native dilatory methods of carriage are exchanged for cheap, quick, and safe means of communication. On all hands, the advantages which it is within our power to give to our fellow-subjects in British Burmah, the natives of Siam, and the people of the Shan States, would be eagerly welcomed by all these populations. The Burmese have already shown, as stated by Mr. Holt Hallett, a pronounced taste for travelling, so much so that, whereas the passenger traffic on the Indian lines contributes one-third of the total receipts, in Burmah it contributes two-thirds. The people of the Shan States, as well as their rulers, have, from the time of McLeod's visit to that of the travels of Mr. Hallett, constantly expressed themselves anxious to see a quicker and better way to foreign markets opened to them; and the King of Siam has promised his support to an undertaking which, with the enlightened wisdom which characterises him, he foresees will be of inestimable benefit to his subjects.

It cannot be too often impressed on the people of this country that the time has gone by when the whole world outside Europe and America was at their feet either to leave or to take. In past years we were the only Power that was driven, by stress of population and commercial necessities, to annex colonies, and to seek new markets for our goods; but at the present day we are jostled in every quarter of the globe by Americans, Frenchmen, Germans, Italians, and Russians, who are all possessed by the desire to secure for their countrymen the advantages which we used to regard as our rights. The old policy of waiting for a convenient season to develop a trade or secure a colony is now out of date, and it behoves us not to lose any opportunity of acquiring new outlets for our manufactures. For some years past the competition which our goods have met with in the markets of the East, has caused a shrinkage in our exports; and it is of vital importance to us that every effort should be made to compensate for losses sustained in the ordinary fields of commerce, by utilising "fresh woods and pastures new" in other directions. The question, therefore, of opening up the Golden Road to China is essentially a manufacturers' question and a workman's question. It is from the factories of Manchester, Birmingham, and Glasgow, and the shipyards of the Tyne that the pressure must be brought upon the Indian Government to put out their hand to pluck the fruit which is ripe for their acceptance. All that is asked from them is that they should guarantee the interest on £916,166, the calculated cost of the branch line to Maulmein, and surely such a deal of sack would be well purchased by such a halfpenny-worth of bread. But supposing the opportunity to be lost, what would be the alternative. The answer is not far to seek. A refusal on our part would leave the way open to the French, who are eager to advance their influence westward in Indo-China. The desire to possess the central Asian Khanates is not stronger with the Russians than is the craving on the part of the French to found an Empire in Indo-China as a counterpoise to our possesions in India. It is openly discussed by the exponents of French public opinion, and is fully recognised by their officials and commanders in the East. Already Cambodia has been drawn into the confederation which is been gradually built up by the French, and with the conquest of Tongking, the command of the whole littoral from the borders of China to the Siamese frontier falls under their

control. A predominating influence over the Siamese railway would advance them a step further towards the fulfilment of their scheme, and would practically do much to interfere with our chance of securing any trade along the line of the Golden Road. It is not long since that the French Under-Secretary for the Colonies announced in the Chamber of Deputies that a Customs union had been formed from China to Siam, within the limits of which French goods were to be exempted from 75 per cent. of the import duties. No greater condemnation of French commerce could be passed than is implied by this stipulation; a trade which requires for its maintenance such artificial supports must be in a weak-kneed condition, and we need have no fear of its seriously competing with our commerce in any open market in the world. But it is the prohibitory effect of such one-sided regulations that would be likely to interfere with our merchants, and any market from which English, German, and American merchants are excluded must practically remain in the hands of the natives from whom the French are quite unable to wrest it. The one fact that, after twenty years of French rule, there is at the present moment at Saigon only one French merchant, speaks for itself. To permit French influence to preponderate in Siam would go far towards closing the markets of the Shan States and of South-Western China to the European nations generally, and of stunting the development of those countries. An opportunity is now afforded us of opening to the world this great field of commerce, and if we miss it we shall have to "ravel out our wear'd up folly" in long years of waiting and disappointment. As I have already said, there is no difficulty, either physical or political, in the way of constructing a railway from Bangkok and Maulmein to Kiang-tsen, but at that point the need of careful diplomacy becomes felt. Any attempt unduly to urge the Chinese Government to allow a railway to be made into Yunnan would probably end in discomfiture, as the attempt of the French to induce the Peking authorities to sanction a line from Canton to Lang-son, in Tongking, has already done. We should build the railway to Kiang-tsen on the threshold of Chinese territory, and there await the course of events. The Chinese are as much a nation of shopkeepers as we are, and when they touch, taste, and handle the advantages gained by a railway to their frontier, they will be readily tempted to carry it into the interior of the country. But whatever is done must be done quickly. Steps should at once be taken to get accurate surveys made of every mile of the proposed railway, and careful estimates of the population and commercial capability of each district through which it would pass. If we shelve the matter for a more convenient season, we shall find some day that others have stepped in and carried off the prize. Now is the time to be up and doing, and I cannot too strongly urge upon this Society the importance of at once grappling with the question, and of doing its utmost to secure for British goods a free admission into this, one of the richest markets in the East.

DISCUSSION.

Mr. HOLT HALLETT, being called upon, said he had not come prepared to speak, but he would give some information which he had gathered in his travels in this country. The routes he had followed were shown by red lines on the large map on the wall; and they passed over the different passes across the hills, so as to find the easiest route to carry the railway. The further you went north along the Irrawaddy, the higher the ranges became; in the north of Yunnan, and in Szechuen, where Mr. Baber crossed, he was amongst the snow; lower down, where Mr. Colquhoun crossed, the hills were about 9,000 feet high; and further down still, about the latitude of Kiangtung, where Dr. Kitchen made the journey across from Mandalay, the passes were about 6,000 feet high. On the journey from Maulmein there was only one main range to be crossed, but owing to the formation of the country, many of the streams which were formerly impounded by the ranges of mountains having broken through, there would be great difficulties in constructing a line along that route. The Chief Commissioner of British Burmah had got out an estimate for the piece of line between Maulmein and Muainghaut, which would be about £900,000. The utmost cost between Maulmein and Raheng would not be more than two millions. Between Raheng and Bangkok there were about 288 villages, and there was very little doubt that the line would pay, as it would pass through a rich delta nearly all the way. Between Zimmé and Bangkok there were about 400 villages. Previous to his journey, nothing was known in Europe of this country, very few towns or villages being marked on the map. Between Raheng and Lakhon there were 200 villages, and above Lakhon, going towards Kiang-tsen, about 45 more. One of these villages, Penyon, contained about 300 houses, and each house usually contained seven or eight inhabitants. The country towards Kiang-tsen was, up to 1881, nearly destitute of population, owing to the fact that in 1797 the Siamese Shans attacked

the Burmese States and took the country, and from that time a continual predatory warfare was kept up along the debateable land. Since the Burmese Shan States had thrown off the yoke of Upper Burmah, they had agreed on a boundary, and when he was there many villages were already settled along that boundary line to the west of Kiang-tsen; one of which contained 230 houses. Throughout his journey he met large caravans of emigrants proceeding to the Kiang-tsen plain. In the same way the Shans from Kiang-tung were going down on the other side. Mr. Hallett then proceeded to describe, by reference to the map, the nature of the country, and the approximate area of the various fertile plains lying between the mountains, many of which appeared to be the beds of ancient lakes or inland seas, whose waters had broken through their barriers and drained away. In the big plain of Zimmé he passed for about 40 miles through paddy land; which must be about 70 miles long. One very interesting fact, showing the enormous opening there was in this part of the world, was, that the missionaries and merchants informed him that in the whole delta of Bangkok one-half the population were Chinese. Now that America had shut its doors to Chinese emigration and Australia also, this country was not only the nearest but almost the only field for Chinese emigrants. There were lines of steamers from Hongkong and some other port, the name of which he had forgotten, to Bangkok, two or three times a month, and there was no doubt that, if taxation were reduced, if the oppression which, in spite of the efforts of the King of Siam, still existed were put down, and if the country were opened up by a railway, an enormous number of Chinese would settle there. Mr. Carl Bock stated the distance between Raheng and Bangkok somewhat differently from himself, but the former went up a considerable distance in a steam launch, which considerably reduced the time occupied. These distances were taken from Mr. Stephens, who had lived many years at Raheng, and who obtained for him the time occupied by the native boatmen.

Professor Douglas said he did not think there was any real discrepancy between Mr. Hallett's calculation and Mr. Carl Bock's. Mr. Carl Bock spoke of the time as dependent on the state of the river, and admitted that it would be much longer at some times than at others. Probably, twelve days would be the average length of time, under favourable circumstances.

Mr. Trelawney Saunders said he had taken great interest in this subject for many years. Something like fifty years ago, when the Indian Government promoted an investigation of this country, Major-General McLeod, then a Captain, advanced as far as Kiang-tung, but was prevented going further by the opposition of the Chinese frontier authorities. Dr. Richardson also contributed largely at that time to our knowledge of this ground, and pointed out that there were remains of an ancient city lying on the Burmese Shan plateau, sarcophagi, mummies, and other indications representing ancient Egyptian commerce in that direction. In fact, there was no knowing what obstruction of intercourse had been brought about by the destructive operations of Mohammedanism; but it might be our lot to see these land roads once more opened up. Many efforts in this direction had been made for the last twenty-five or thirty years by the late Captain Sprye, who spent his life and substance in trying to open up this country by means of railways. He hoped sincerely that the gentlemen who had taken up the thread where Captain Sprye left it would be more successful. A remark had been made by Mr. Hallett with reference to the oppression exercised by the Siamese Government, notwithstanding the well-known liberality and enlightenment of its rulers. The sovereigns had distinguished themselves by the interest they had shown in everything tending to the enlightenment of their subjects, but still they were not able to overcome the hereditary tendency of their subjects to practices which were not favourable to our idea of commerce; and those things he thought would stand very much in the way of European investments in the construction of railways in a foreign territory over which we had no control. Until some way were found to establish legitimate control over such a work, he could not see the probability of its being accomplished. At the same time we must not allow ourselves to be blocked out altogether from an approach to China from the west. A remarkable instance of what might be done to promote intercourse was shown in what had been accomplished by the native explorer sent out by the Indian Government, who came from Sz'chuen to within thirty miles of the Indian frontier at the end of the Assam valley, and was simply prevented passing over that distance by the unconquerable obstruction of the Mishmee-hill tribes. By that route there were only two great rivers to be crossed, the Mekhong and Salween; it headed the Irrawaddy, and beyond the Salween the passage into India was along a tributary of the Brahmapootra. There might be engineering difficulties in overcoming that part of the route, as well as the difficulty of crossing these two great rivers, which were, nevertheless, bridged by the Chinese and Thibetans. By that route China came within 150 miles of the borders of India. Up to Sudiya there was a steamboat and partial railway communication, with which the advance of commerce would no doubt be extended. The difference between making 1,000 miles of railway in a foreign country and 200 miles was very great. At any rate they might hope that the accomplishment of direct communication between the Bay of Bengal and Western China was not an idea altogether to be abandoned, and things moved so rapidly in these days that he yet hoped to see it fulfilled.

Mr. Fung Yee (Secretary of the Chinese Legation)

said he had come there to listen, for Professor Douglas knew China as well as he did himself. That was a Society for the Encouragement of Arts, Manufactures, and Commerce; and Professor Douglas had taken up the commercial question, which was perhaps the most important of the three, because it concerned the welfare of different nations, and it was very desirable that every nation should promote commerce as far as lay in its power. Several routes had been proposed to reach South-Western China, each of which had its merits, and these required to be very carefully considered. The subject might be approached from several points of view—the political, commercial, social, and financial. He would leave the political side of the question to be considered by those who were concerned in it; but he had no doubt that one day this communication would be made, and he hoped the day was not very distant. The most important thing was for the different countries to thoroughly understand the advantages which they would derive from such a route, and those who took up the matter should promote it, not from personal or party motives, but from a cosmopolitan point of view. On the social side of the question, he would say that different nations who had commerce with each other should study each other's interests, and not simply to promote their own at the expense of others; it was only when the mutual interests were consulted that success would be insured. Commerce was a very important thing, and required further development; and in dealing with the Chinese market it was very desirable that English manufacturers should send genuine articles, and supply them at a price which every one could pay. For instance, many of the cotton goods which were sent to China were too much sized, and he was quite certain that if better articles were sent, there would be a larger market. Again, English merchants in China should see that articles exported from there were not adulterated. Like all his countrymen, he was very fond of drinking tea, but he found it very different here to what he got in China. Many people blamed the Chinese for sending bad tea, but the fault really lay with the merchants. Green tea in China was a very beautiful and wholesome beverage, but when he attempted to make it with what was called green or gunpowder tea in England, half of the liquid was like mud. With regard to the financial point, the expense of building a line would be so great, that the question would be, would it pay? China was a very populous country, but the people were poor, and travelling must be very cheap, or the line would not pay. In conclusion, he expressed his gratitude to Professor Douglas, whose efforts in promoting the welfare of the Chinese were well known to all his countrymen.

Mr. Hyde Clarke said the conclusion of Mr. Saunders' remarks was far better than the beginning, and he fancied that, with all his knowledge, he had not brought together all the facts which bore on this question. If he had thought for a moment, he would have recollected that since Captain Spry had spoken in that room, railways had penetrated into British Burmah, and those two lines which had been spoken of by Professor Douglas constituted in themselves a very great encouragement for the further development of the enterprise. They were two of the best State lines in India. Then came the question of the continuation from the branch of the Toungoo line to reach Raheng. There was no doubt that would be made, but the question was, who was to find the money for it? The fact was that the province of British Burmah itself could, from its surplus, supply in one year the capital required for making that extension, and there could be no difficulty in the Indian Government undertaking the guarantee, which, as Professor Douglas said, was not an effective payment; the Government would simply have to guarantee any deficiency that there might be on that continuation line. The more this was looked at from a practical point of view, the easier its solution became, and the more imperative it became on the part of the Indian Government, in the first instance, to commence operations before it was too late. As a practical man, he would say there was no engineering difficulty and no financial difficulty. Then came another point which had frightened Mr. Saunders very much, and that was the Siamese part of the line, but he had forgotten that a railway was the very thing which would enable the King of Siam to deal with his own officials, and to promote the welfare of the whole country. Anyone who had been in Eastern countries, and had seen the working of a railway, knew that it was one of the most powerful instruments of government which an administration could possess. In this country there was such an advanced state of civilisation, that we hardly knew the full value of the implements we possessed. There was hardly a Government in the world but knew that when it had a railway it could apply its military and police force locally with the greatest effect, and thus the very difficulty which Mr. Saunders had rightly described would disappear. With regard to the financial question, speaking practically, there was not a capitalist in the country—and if we did not do it capitalists on the continent would—who would hesitate to find the money if proper measures were taken. The revenues of Bangkok were sufficient, if a lien were given on the customs, to enable all the requisite monies to be raised for constructing that railway. Looking at all these circumstances together, the whole undertaking would be seen to be absolutely practicable. The first step was that we should ourselves advance and make the junction; then the Siamese Government would be encouraged to make the line from Bangkok to Raheng, and the upper line would follow as a matter of course. If the line from Bangkok to Raheng paid, that Government would not be called upon for a penny, and there would be no difficulty in raising the capital for the extension. There had

never, perhaps, even in the experience of the chairman, been a question brought before the Government of India so important in itself, and so easy in its solution, as the construction of this line. It would go on step by step in a practical way if it were once commenced. They had heard the enlightened sentiments of Mr. Fung Yee, and if they went up to the frontier, the Chinese Government would no doubt be still more encouraged to carry out the undertaking. The previous day he had been looking at an old London Directory for 1793, and there he saw that the Society of Arts had in those days a chairman of committees for colonies and for commerce. At that period, therefore, they had commenced in this good work, and he trusted they would continue to do so to the utmost.

Mr. Maclean said he was not familiar with this part of the country, but it was perfectly plain that the construction of such a railway would be a very useful and beneficial work. He had been struck, however, with some of the remarks made by Mr. Hyde Clarke as to the Government of India providing a guarantee for this line, and the same idea was mentioned by Professor Douglas. Now, he should like to know on what ground the Government of India could be called upon to guarantee the payment on a railway running up the valley from Bangkok into South-Western China.

Mr. Hyde Clarke said he made no such proposal.

Mr. Maclean said of course on their own territory it was a different thing, but he felt he ought to protest against the idea that the Government of India should take any special pecuniary interest in a railway running through Siam. The arguments brought forward were that it would be a benefit to English traders, and would open new markets, but if that were so, why should not a rich country like England find the money? The people of this country were rather fond of asking the Indian Government to find guarantees for anything they wanted to do. It would be much better if there were more of the spirit of the old merchant adventurers, who pushed into distant markets and engaged in great enterprises at their own cost. But, again, how was it likely that a railway of this kind would be promoted by English capitalists, unless they had some security for the good government of the country? On the great continent of America, they saw numerous lines of trunk railways 3,000 miles long; that arose simply because all over America there was an excellent system of government, and therefore these vast systems of railway communication could be established. On the other hand, if you looked at the immense continent of Asia, you saw the most fruitful countries in the whole world, capable of producing the most valuble products, which were absolutely destitute of railways; from the shore of the Mediterranean right down to the Persian Gulf there was hardly a mile. What was the reason? Simply because there was no government in that part of the world; the so-called government was simply a system of legalised brigandage, and nothing else, the only object being to drag as much as possible out of the people and do nothing for them in return. The first thing necessary when proposals of this kind were brought forward was to see some just and good government prevailing in the country. What was the cause of the desperate financial condition of Egypt at present? Simply because the system of government had been so bad that the rulers could only borrow money for public works at an enormous rate of interest. Very much the same thing would exist in Asia; and how were railways to pay if money was only lent at a high rate of interest? The beginning of all progress in the East was the establishment of some sort of good government. For that reason, it would be an advantage if the arm of England could be stretched out farther over countries in the East, and if we were not content to shut ourselves up in our own present dominions, but try to improve the condition of the countries beyond. It was only in that way that we could get large public works constructed in those countries.

The Chairman said he could only speak with great diffidence on this subject, being utterly unable to pronounce most of the names which had been mentioned, and it was very difficult from any atlas to get much information, for the fact was that our map-makers did not know much of this country at present. It was one of the difficulties that Professor Douglas had to deal with that you had to educate the English mind gradually to a knowledge of what there was to be found in these countries. When at the India-office he had had to deal with some of the neighbouring districts, and had often had his attention called to Karennee, which had that kind of indistinct boundary which was frequently a source of so much trouble. With regard to the Shan States, however, we had some definite information, and there was no doubt the prospect of a very good trade being carried on by some route of this description between India and the souih-west districts of China. No one could follow Mr. Hallett's description of the country without seeing that there must be a large population, and there was a prospect of a considerable trade being developed by degrees. He had been also struck with the observation made by Mr. Saunders about the great difficulty presented by the fact of having to pass through foreign States; and here he would ask Professor Douglas a question. They had heard the Shan States spoken of as being Burmese and also as being Siamese, but they also heard of some of those States paying tribute to China. If they had three foreign countries to deal with, it increased the difficulties of which Mr. Saunders had spoken. At the same time, from what they knew of the Government of Siam, there was every hope that no great difficulty would be presented in our relations with that country; and again in dealing with China, the

excellent relations we now had with that country, and the remarks of the Secretary of the Chinese Legation showed that in that direction we should before long have very little difficulty to meet with; but if the Burmese entered into the question, he feared there would be considerably more difficulty. With regard to the railway, he should much prefer that it should take a direction connecting the districts of South-Western China rather with the Indian Ocean than with the Gulf of Siam for many reasons; but, from what had been heard that night, it appeared there would be considerably greater physical difficulties in carrying a railway in that direction. Of course, some of those might disappear on further survey and examination, for it could not be pretended that this country had been thoroughly surveyed, and further investigation might reveal other routes, of which at present we knew very little, more suitable for a railway. With regard to the financial aspect, it was premature to talk about the amount of money required, for their information was too small; but the question was, how was it to be constructed? He agreed with all Mr. Maclean had said with regard to the Indian Government. It was impossible to hold that the Indian Government was bound to provide a guarantee for any line beyond the frontier, and he was quite sure Mr. Douglas would agree in that view. There was even considerable objection in the Indian Government carrying the system of guarantee in any case beyond a certain amount, but when Mr. Maclean talked of going back to the spirit of the old merchant adventurers, he would remind him that those men had not made many railways in India without a guarantee. He trusted that before long English capital would be attracted to India, and spent in the construction of public works without a guarantee. Outside the frontier of course they could not expect any such guarantee. There might be hopes that the Siamese would, in due time, be induced to commence this work, but in any case there might be sufficient ground for the Indian Government to give all the support to the enterprise within its power, and some means might be found whereby, although the line was not guaranteed, it might receive such countenance as would greatly assist the enterprise. Its construction depended on confidence, and confidence was a plant of slow growth. Capital would only be attracted when people were satisfied of the feasibility of the scheme, and the reasonableness of the cost, and the prospects of a return within a reasonable time. All these things yet required to be proved, and it could only be done gradually; they were, therefore, much indebted to anyone who, like Professor Douglas, could bring together the knowledge gathered by various travellers in this district, and gave so exceedingly clear and able account of what was known about the Shan States, and he would conclude, therefore, by proposing a cordial vote of thanks to him for his paper.

The vote of thanks having been passed,

Professor DOUGLAS, in reply, said the Shan people were for the most part immigrants into the mountainous districts on the frontiers of China, Siam, and Burmah, having been driven from their original seats, many of them from Central and Western China. The advance of the Chinese from the North had driven them southwards by degrees, until they had been compelled to cross the southern frontier into the Shan States. Those in the neighbourhood of the Chinese frontier were subject to the guidance and influence of the Chinese Government. The Shans on the south of Kiang-tung were for a long time under the influence of Burmah, but in the year 1879, they rebelled, and established their independence. Southward of these were the Shan States which were dependent on Siam; virtually therefore, we had only to deal with the Siamese and Chinese Governments.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The number of visitors to this Exhibition for the week ending 26th May was 176,612. Total since the opening 396,313.

The Loan Exhibition of Musical Instruments is now being arranged in the Galleries of the Albert-hall. It will be opened next week.

EXPORTS OF WOOL FROM TURKEY.

The following particulars respecting the supplies of Turkey wools to this country have been sent by Messrs. Willans and Overbury, as bearing on a note in a previous number of the *Journal* (see p. 721). The official returns show that the imports into this country have widely fluctuated during the last ten years, owing probably to the, at times, low range of prices ruling in this market, and to the reluctance of holders in Turkey to accept these prices until fully established; so that the present is by no means the first occasion of a season's old stock remaining in that country. No separate account is kept of the relative quantities of Kassapbatchi and other Turkey sheeps' wool imported into this country, but when it is borne in mind that many shipments are now made direct to the United States which formerly passed through Liverpool, and that Marseilles imports a much larger proportion of the Turkey clip than formerly, it is probable that the nett diminution of exports is not so great as 50 per cent. The subjoined Tables show, the one the imports of wools (not exclusively from Turkey, but in which all shipments from that country and its dependencies are included), and the other the average prices realised for special descriptions during the past ten years:—

IMPORTS.

Year.	Mediterranean.	Egyptian.	Turkey Goats Wool.
1875..........	13,522	4,528	31,488
1876..........	14,406	5,881	24,832
1877..........	17,292	5,724	33,853
1878..........	15,708	4,723	27,175
1879..........	6,425	3,601	32,654
1880..........	22,343	5,104	44,436
1881..........	12,373	3,768	24,818
1882..........	19,580	3,339	51,658
1883..........	37,728	5,050	30,688
1884..........	16,271	4,298	45,711

AVERAGE PRICES.

Year.	Mohair, fair average.	Angora.	Smyrna.	Kassapbatchi.	Egyptian, best white.
	s. d.	s. d.	s. d.	s. d.	s. d.
1875..........	3 8½	1 1	0 11½	no account	1 3½
1876..........	3 2	1 0½	0 11		1 3½
1877..........	2 11	0 11½	0 10		1 2½
1878..........	2 6	0 11	0 9½	0 9½	1 1½
1879..........	1 10	0 10	0 8½	0 8¾	1 1
1880..........	2 5	1 0½	0 10½	0 10½	1 4
1881..........	1 9	1 0	0 10	0 9½	1 2
1882..........	1 9	0 11½	0 9½	0 9	1 1½
1883..........	1 7½	0 10½	0 9	0 8¾	1 1
1884..........	1 8	0 9	0 8	0 7¾	0 11½
1885..........	1 5	0 8½	0 7½	0 7¼	0 11

Obituary.

JEREMIAH COLMAN.—Mr. Jeremiah Colman, of Carshalton-park, head of the firm of Messrs. Colman, mustard manufacturers, who had been a member of the Society of Arts for thirty years, died on Thursday, 21st inst. Mr. Colman, who was aged seventy-six at the time of his death, was one of twelve sons of the late Mr. Robert Colman, a tenant farmer for over seventy years at Rockland, Norfolk, who died at the age of ninety-two. He joined the Society in 1855.

GAS INSTITUTE. — The Twenty-second Annual General Meeting of the Members of the Institute will be held on Tuesday, Wednesday, Thursday, and Friday, 9th—12th June, at the Memorial-hall, Albert-square, Manchester. The members will visit manufacturing and other works, and on Friday there will be an excursion to Southport.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 1 ... Engineers, Westminster Town Hall, S.W., 7½ p.m. Mr. Henry Faija, "Portland Cement."

Chemical Industry (London Section), Burlington-house, W., 8 p.m.

Surveyors, 12, Great George-street, S.W., 3 p.m. Annual General Meeting.

Inventors' Institute, Lonsdale-chambers, Chancery-lane, W.C., 8 p.m. Further Discussion of Patent Law, 1883.

TUESDAY, JUNE 2...Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Annual General Meeting.

Biblical Archæology, 9, Conduit-street, W., 8 p.m. 1. Rev. Henry G. Tomkins, "The Topography of Northern Syria, with special reference to the Karnak Lists of Thothmes III." 2. Mr. Theo. G. Pinches, "Specimens of the Familiar Correspondence of the Babylonians and Assyrians." 3. Prof. A. H. Sayce, "The Site of Thîs."

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. Frank E. Beddard and Mr. F. Treves, "The Anatomy of the Sondaic Rhinoceros." 2. Dr. Julius von Haast, "*Megalapteryx hectori*." 3. Dr. Guillemard, "The Birds collected during the Voyage of the Yacht *Marchesa*." Part IV. "The Collection of Birds from Celebes." Part. V. "The Collection of Birds from the Moluccas."

WEDNESDAY, JUNE 3...Entomological, 11, Chandos-street, W., 7 p m.

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. T. G. Pinches, "The Inscriptions and Art of Babylonian Cylinders." 2. Mr. J. Romilly Allen, "Recent Discoveries of Pre-Norman Sculpture." 3. Mr. J. T. Irvine, "The Saxon Church of Barnack."

Obstetrical, 53, Berners-street, W., 8 p.m.

THURSDAY, JUNE 4...Society for the Protection of Ancient Buildings (at the HOUSE OF THE SOCIETY OF ARTS), 3 p.m.

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Rev. George Henslow, "Vernation and Development of Foliage from Buds." 2. Dr. Maxwell Masters, "Supplementary Notes on *Restiaceæ*." 3. Mr. R. Kidston, "Occurrence of *Lycopodites Vanuxemi* in Britain, with remarks on its affinities."

Chemical, Burlington-house, W., 8 p.m. 1. Ballot for the Election of Fellows. 2. Prof. Meldola, "The Constitution of the Haloid Naphthaline Derivatives."

East Indian Association, 14, Bedford-row, W.C., 8 p.m.

FRIDAY, JUNE 5...Royal Institution, Albemarle-street, W., 3 p.m. Weekly Meeting. 9 p.m.

Civil Engineers, 9 p.m. Conversazione at the International Inventions Exhibition.

Geologists' Association, University College, W.C. 7½ p.m. Special General Meeting to amend Rules of the Association. 8 p.m. 1. Mr. Herbert Goss, "Some recently discovered Insecta and Arachnida from Carboniferous and Silurian Rocks." 2. Mr. J. G. Goodchild, "Notes on the Superficial Deposits of North Kent."

Philological, University College, W.C., 8 p.m. Paper on "Stress in Greek, according to indirect evidence," by the late Mr. C. B. Cayley.

SATURDAY, JUNE 6...Geologists' Association. Excursion to Reading.

Journal of the Society of Arts.

No. 1,693. Vol. XXXIII.

FRIDAY, JUNE 5, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ALBERT MEDAL.

The Council of the Society of Arts have (with the approval of the President, H.R.H. the Prince of Wales) awarded the Albert Medal to Henry Doulton, "in recognition of the impulse given by him to the production of artistic pottery in this country."

MEDALS.

The Council have awarded the Society's Silver Medals to the following readers of papers during the Session, 1884-5 :—

To Anton Jurgens, for his paper on "The Preparation of Butterine."

To P. L. Simmonds, for his paper on "Present and Prospective Sources of the Timber Supplies of Great Britain."

To A. J. Ellis, B.A., F.R.S., for his paper on "The Musical Scales of Various Nations."

To Thomas Wardle, for his paper on "Researches on Silk Fibre."

To H. H. Johnston, for his paper on "British Interests in East Africa, especially in the Kilimanjaro District."

To. E. C. Buck, for his paper on "The Agricultural Resources of India."

To Mancherjee M. Bhownaggree, for his paper on "The Present Condition and Future Prospects of Female Education in India."

To Dr. Frederick Siemens, for his paper on "Tempered Glass."

To Frederick J. Lloyd, for his paper on "The Chemistry of Ensilage."

Thanks were voted to the following members of Couneil for the papers read by them : —

To W. H. Preece, F.R.S., for his paper on "Electric Lighting in America."

To R. Brudenell Carter, F.R.C.S., for his paper on "The Influence of Civilisation upon Eyesight."

To Capt. Douglas Galton, C.B., F.R.S., for his paper on "Report of the Royal Commission on Metropolitan Sewage."

To B. W. Richardson, M.D., F.R.S., for his paper on "Removal of House Refuse independent of Sewage."

To Prof. James Dewar, F.R.S., for his paper on "The American Oil and Gas Fields."

WESTGARTH PRIZES.

The Committee appointed by the Council to consider the Essays sent in for the above prizes, have reported to the effect that in their opinion none of the Essays realise the requirements of the offer in such a manner as to justify them in recommending that the full amount of the prizes offered by Mr. Westgarth should be awarded. They recommended, however, that prizes amounting in all to £600 should be awarded as under:—

Three prizes of £100 each, to H. H. Bridgman, 42, Poultry, E.C.; J. Corbett, 24, Barton-arcade, Manchester; W. Woodward, 7, Duke-street, Adelphi, W.C.

Three prizes of £50 each, to A. Wynter Blyth, Court-house, St. Marylebone, W., and R. Greene, Berry Wood, Northampton; Clement Dunscombe, City Engineer, Liverpool; C. Scott, Town Hall, Belfast, and J. W. E. Tilley, Royal-avenue, Belfast.

Six prizes of £25 each, to A. H. De Wind, Comber, Co. Down; J. S. Fairfax, 3, St. Paul's-road, Camden-square, N.W.; Victor Jetley, 8, North Audley-street, W.; T. E. Julian, 22, Palace-road, Roupell-park, S.W.; W. H. Newell, M.D., 201, Palisade-avenue, Jersey City, N.J., United States of America; G. W. Usill, Haldon-lodge, Southfields, Wandsworth, S.W.

The Council, after consultation with Mr. Westgarth, have accepted the report of the Committee, and awarded the prizes as recommended. It has been determined that the three Essays to which prizes of £100 were awarded shall be published on behalf of the Society.

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by the kind permission of the Executive Council of the International Inventions Exhi-

bition, in the Exhibition-buildings, South Kensington, on Friday, the 3rd of July next.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. In addition to this, cards will be sold to members of the Society, or to persons introduced by a member, at the following prices:—Until the 20th of June, 5s. each; from that date until the 30th of June, 7s. 6d.; on the 1st, 2nd, and 3rd of July, 10s. each.

The Council, however, reserve the right of stopping the sale of tickets or of raising the price, if it is found necessary, in order to restrict the number of visitors within reasonable limits.

Tickets will only be supplied to persons presenting members' vouchers, (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter, a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase. It will greatly facilitate the arrangements if members requiring additional tickets will apply for them at as early a date as convenient. The members' invitations will be issued early in June. Visitors' tickets can be purchased from the present date.

There will be no admission to the Exhibition on this evening except by special ticket, and no tickets can be purchased at the Exhibition.

Tickets are now in course of issue to members.

Proceedings of the Society

HOWARD LECTURES.

ON THE CONVERSION OF HEAT INTO USEFUL WORK.

By William Anderson, M.Inst.C.E.

Lecture VI.—Delivered February 5th, 1885.

I have now reached the stage of my lectures when it becomes necessary to consider heat-engines proper, that is to say, mechanical contrivances more or less complicated, whereby the heat imparted to the agent is converted into work; but before I begin, I must introduce you to a little instrument called the indicator, which is used for the purpose of depicting automatically the changes of volume and pressure which take place in the agent when a heat-engine is working. Nearly all heat-engines are actuated by heated expansive gases pressing upon pistons working in closed cylinders or spheres, and the amount of work which is performed is proportional to the volumes described by the pistons, multiplied by the mean pressure exerted against them. The indicator is merely a small working cylinder which can be placed in communication with that of the engine. The cylinder has usually an area of half a square inch, and is fitted with a piston, to the rod of which is attached a pencil, arranged so as to trace a line on the paper-covered roll which is made to rotate with a reciprocating motion at a speed proportional throughout to that of the piston of the engine. The indicator piston is held down by a spring, the elasticity of which is accurately known. When there is no communication between the two cylinders, and while the paper-roll is turning backwards and forwards isochronously with the piston of the engine, if the pencil be applied, a straight line will be traced; this line will represent the atmospheric pressure, or one atmosphere. As soon as the connecting cock between the cylinders is opened, the indicator piston, with its rod and pencil, commences at once to follow the movements of the larger piston, the range of motion depending on the pressure inside the large cylinder, the indicator spring yielding till its elasticity is balanced by the pressure of the agent. The pencil, if now applied to the paper, will trace a closed curve which represents, in the direction of the atmospheric line, the distance passed over by the main piston, and, in the ordinates at right angles to the line, the pressures above or below the atmosphere. The area of the figure represents the work done, if the length of it along the atmosperic line be considered to represent the volume of the cylinder.

The indicator diagram, therefore, is a figure which represents, with tolerable exactness, the changes of volume and pressure which take place in the working substance throughout a complete cycle.

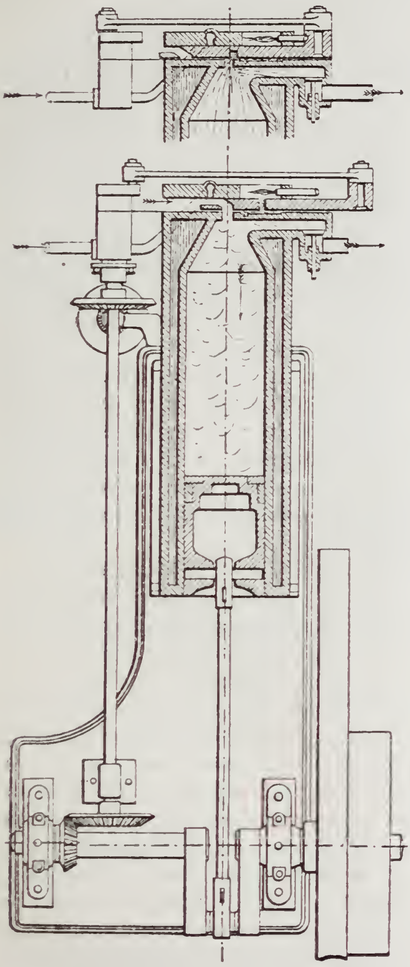
The Gas-engine. (Fig. 37, p. 805.)

In the case of the explosion of gunpowder in firearms, the working of the machine is intermittent. In repeating guns, indeed, an

approach is made to continuous working, though not in an automatic manner, but in gas-engines the force of explosion is made to imitate closely the action of a steam-engine.

The most successful of these motors is that known as the "Otto Silent Engine." I will, therefore, adopt it as a type of this class of apparatus designed for the conversion of heat into useful work. The engine consists of a

FIG. 37.



cylinder fitted with a piston, the rod of which actuates a connecting rod, and by its agency a crank shaft, on which is keyed a fly-wheel, the whole arrangement resembling very much that of an ordinary horizontal engine.

The cylinder is longer than the stroke of the piston, so that at the rear end there is a space or chamber, having a volume of about 61 per cent. of the displacement of the piston. The other end of the cylinder is open to the atmosphere, and therefore the engine is single-acting—that is, the pressure of the working agent comes only on one side of the piston.

Not only is the engine single-acting, but the piston receives an impulse only once in every two revolutions of the fly-wheel, or once in four strokes. During the stroke in which the impulse is given—which lasts one-fourth of the complete cycle—the pressure accelerates the motion of the fly-wheel and other moving parts, and the energy so accumulated is given out during the remaining three-fourths of the cycle. The velocity of rotation necessarily varies in a proportional degree. For the purpose of keeping the cylinder cool, it is surrounded by a jacket, through which a stream of water continually circulates.

A complete cycle consists of the following operations :—

1. The piston makes a forward stroke, and draws in a supply of gas and air through a slide valve in the rear of the cylinder. At the end of the stroke, the slide valve closes the passages ; and

2. The piston makes a return stroke, and compresses the air and gas into the chamber at the rear end of the piston.

3. The explosive mixture of gas, air, and the residue of the products of combustion of the previous stroke is ignited, very rapid combustion, rather than explosion, takes place, and is barely completed before the piston attains the end of its second forward stroke. The heated gases expand, giving out work, and accelerate the motion of the moving parts. When the end of the stroke is nearly reached, the exhaust valve is opened, and

4. The piston in its second return stroke partially drives out the production, and restores everything to the same condition as it was at the beginning of the cycle.

Pursuing the plan I have adopted in these lectures, I will discuss this prime mover in connection with an actual example, viz., that of a ten horse-engine experimented on by Messrs. Brooks and Steward, at the Stevens Institute of Technology in New York, in the year 1883.

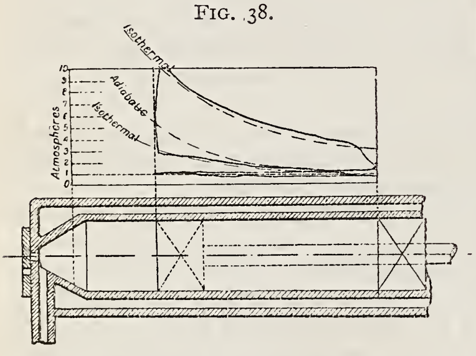
This engine had a cylinder $8\frac{1}{2}$ in. diameter by 14 in. stroke. I will select experiment No. 19, made when working full power. An indicator diagram (Fig. 38, p. 806) was taken, and it sets before you all the changes which took place during one of the cycles. Let us consider the four strokes in detail.

1. The first outward stroke.—The indicator

diagram shows that a vacuum, amounting to ·15 of an atmosphere, or 2·2 lbs. per square inch, was produced in drawing in the air and gas, the exact quantity of which, consumed during the 30 minutes run, was measured by accurate meters and found to be 3·76 lbs. of gas and 60·38 lbs. of air, being in the proportion of 1 : 16. The gas used was of inferior quality, and required only $12\frac{1}{2}$ lbs. of air per 1 lb. of gas for perfect combustion, so that the quantity actually used was 28 per cent. in excess. With good gas, such as is generally supplied to London, you will see, from the table of "Properties of Fuels," that 15·66 lbs. of air are required for a pound of gas.

2. In the return stroke, the air and gases were rapidly compressed into a little more than one-third of their volume. The engine made 160 revolutions per minute, so that the compression must have taken place in a little

Fig. 38.



over one-fifth of a second, consequently we should have expected the pressure of the gases to rise nearly according to the ordinates of an adiabatic curve, such as I have traced in dotted lines on the indicator diagram. The water-jacket, however, carried off the heat due to the energy expended in compression so fast, that the curve barely rose above the isothermal, which I have also indicated by a dotted line. The work, which was negative, that is, performed upon the agent, had been done at the expense of the energy latent in the fly-wheel, and had it been possible to prevent the escape of heat, no permanent loss would have been sustained, because the same amount of work would have been given out on the return stroke; but, under the actual circumstances, energy, represented by the difference between the work done along the two curves, has been carried off by the water-jacket, and lost, so far as the engine is concerned.

3. At the turn of the stroke, the explosive mixture is fired by an ingenious arrangement in the slide valve, by means of which a pinch of gas—if I may use the term—is set alight by a jet constantly burning behind the valve, and carried, before combustion ceases, into the passage communicating with the cylinder through which the contents of the latter are ignited.

As you see by the vertical line on the left of the diagram, which represents the rise of pressure due to the explosion, the combustion is very rapid, and its intensity reaches a maximum before half an inch of the stroke is accomplished, or in about one-fiftieth part of a second, the pressure rising from three atmospheres absolute to ten, and then sinking as the volume of the gases increases. The fall of pressure ought to be according to the ordinates of an adiabatic curve; but in reality, as you see by the dotted line which I have introduced into the diagram, the curve rises a little even above an isothermal.

When within about $1\frac{1}{2}$ inches of the end of the stroke, the exhaust valve begins to open, and, 4th, in the return stroke, the products of combustion are expelled at a temperature of 790°, or 1,250° absolute.

The gas used in this case, I have already said, was of poor quality. Mr. Deering has been good enough to calculate its thermodynamic value for me, and he finds that, supposing it to have been saturated with vapour of water, the combustion of 1 lb. would yield 17,096 units of heat.

During the half-hour over which the observation extended, 3·764 lbs. of gas were used, the total weight of complete fuel and products was 84·711 lbs., and 20·568 lbs. of products of combustion at 1,250° absolute remained in the cylinder, consequently the mixture of gas, air, and products, taking due account of the variations of specific heat, must have had a mean temperature of 734° absolute. The indicator diagram shows that the temperature did not change sensibly during the compression of the mixture, hence the total heat of combination was $17{,}096^u + (734^\circ \times \cdot 188) = 17{,}234^u$ per pound of gas, reckoning from absolute zero. The mean specific heat of the gases must here be taken as that due to constant volume, and proves on calculation to be ·188. The absolute temperature should rise to

$$\frac{3 \cdot 764 \text{ lbs.} \times 17{,}096^u}{84 \cdot 711 \text{ lbs.} \times \cdot 188} + 734^\circ = 4{,}781^\circ.$$

if chemical reaction were complete, but this temperature is higher than that at which dissociation takes place, so that it could not possibly be reached.

We can approximate to the true temperature, however, by calculating from the pressures which the indicator diagram declares. The temperature of the mixture of gases before explosion was 734° absolute, at 3 atmospheres pressure; this rose at once to 10 atmospheres, hence the temperature, allowing for the contraction of volume which takes place in the chemical reaction, and for the increase of volume due to the piston having moved forward half an inch, must have been

$$\frac{734^\circ \times 10\,at \times 5\cdot 82v}{2\cdot 964\,at \times 5\cdot 32v} = 2{,}712^\circ \text{ absolute.}$$

This point is not capable of exact determination by calculation, because of the uncertainty as to the specific heats of substances at high temperatures. The true value must be somewhat higher than the figures arrived at, because the indicator, owing to its own friction and inertia, is sure to register the pressures lower than they really are, especially when the action is so rapid, as it is in the case of gas-engines. I think it will be safe to assume that the maximum temperature attained was about 3,000° absolute. Under such circumstances, the duty to be expected, according to Carnot's doctrine would be $= \frac{3{,}000^\circ - 1{,}250^\circ}{3{,}000^\circ} = \cdot 583$, and the total available power for which the engine might fairly be made debtor would be

$$\frac{3\cdot 764 \text{ lbs.} \times 17{,}234^{u} \times 772^{J} \times \cdot 583}{30' \times 33{,}000}$$
$$= 29\cdot 49 \text{ horse-power.}$$

The circumstance that the expansion curve of the indicator diagram follows the isothermal, and not the adiabatic, and the lowness of the temperature when the maximum pressure is reached, show that combustion must continue for at least the whole stroke, and probably even some way along the return. It is only by such a supposition that the heat communicated to the working substance, as it expands, can be accounted for, because the metal of the cylinder, surrounded by its water-jacket, is much cooler than the gases, and, so far from heating, must tend to cool them. Again, working backward from the final temperature of 1,250°, the heat, at the moment of exhaust, should be about 1,800°, calculating from the pressures, whereas it is quite 1,000° higher, the excess being carried off during the return stroke by the water-jacket.

The engine must be credited with the following work:—

1. The indicated power ascertained by measuring the diagram, being the useful external work done = 8½ horse-power.

2. Heating up 9·75 cubic feet of water in the jacket 43·38° Fahr., during the half-hour for which the experiment lasted, this represents—

$$\frac{9\cdot 75 \text{ c. ft.} \times 62\cdot 2 \text{ lbs.} \times 43\cdot 38^\circ \times 772^{J}}{30' \times 33{,}000}$$
$$= 20\cdot 52 \text{ horse-power.}$$

3rd, and finally, a certain amount of loss by radiation, convection, and leakage, amounting to ·47 horse-power.

Dr. BALANCE-SHEET OF GAS-ENGINE. *Cr.*

	Horse-power.		Horse-power.	Per cent.
Available power	29·49	Indicated power	8·5	28·83
		Carried off by water-jacket	20·52	69·58
		Loss by radiation, &c.	·47	1·59
	29·49		29·49	100·00

The water-jacket, which is an unfortunate mechanical necessity in consequence of there being, at present, no other known method of keeping the working parts in a state of efficiency at high temperatures, consumes, as you see, nearly 2½ times as much heat as the useful work given out. The practical efficiency of this particular engine was only 8½ horse-power out of a total of 50·53 possible if the products could have been cooled to absolute zero, this realised, therefore, only 17 per cent. of the energy latent in the gas.

With good gas, it is said that the engines consume only 21 cubic feet per indicated horse-power per hour; a reference to the table of "Properties of Fuels" tells us that 1,000

cubic feet of good gas will yield 617,485 units of heat, hence 21 cubic feet per hour would yield per minute—

$$\frac{617{,}485'' \times 21 \text{ c. ft.} \times 772^3}{1{,}000 \text{ c. ft.} \times 60' \quad 33{,}000} = 5\cdot056 \text{ horse-power}$$

capable of producing only 1 horse-power, so that even good gas will only yield a duty of 20 per cent. Carnot's theory enables us to give a reason for this result. First, the initial temperature cannot be raised to the highest point possible; and, secondly, the terminal temperature is excessively high. In addition, there is the terrible waste in the water-jackets. The theory we have been considering indicates that a higher range of duty is attainable, and I am sure that the time will come when, by suitable mechanical contrivances, better results will be obtained. One method of improving the economy, though not the efficiency, of gas-engines, is to use crude gas, generated in a producer somewhat on Siemens' system. By this means, nearly the whole of the coal is converted into various gases, and is used at once in the engine. The table of the properties of fuels tells us that Wigan coal, for example, produces 14,051 units of heat per 1 lb. of coal. If consumed in an hour this would yield

$$= \frac{14{,}052'' \times 772J}{60' \times 33{,}000} = 5\cdot48 \text{ horse-power, and at}$$

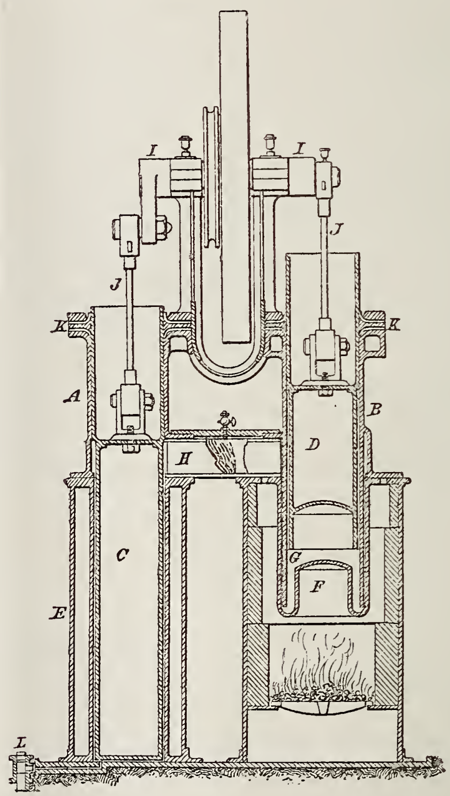
20 per cent. duty should give 1·1 horse-power. As a matter of fact, 1 lb. of coal applied in this way, on a large scale, is yielding seven-tenths of a horse-power. With all its imperfections, however, the gas-engine has taken a firm place as a trustworthy, safe, convenient and even economical contrivance for the conversion of heat into useful work.

Hot-air Engine. (Fig. 39.)

We now come to the investigation of the properties of an agent in the conversion of heat into work, respecting which an immense amount of inventive genius has been employed. I allude to hot air.

Air, being a mixture of gases which do not alter their physical properties through a wide range of temperature and pressures, is peculiarly fitted for illustrating the theoretical aspects of the subject before us. The specific heat of air, at constant volume, when the increase of its temperature is unaccompanied by the performance of external work, is ·169. The pressure of a given volume of air, when heated, increases as its absolute temperature, if there is no change of volume, and, at first sight, it would appear that if air were heated in a confined space and then allowed to expand, doing external work, that the whole of the heat imparted could be converted into work, and the air rejected at the normal temperature and pressure of the atmosphere. If this could be done, a perfect engine would be the result; but the fall of temperature in air, when used as a working agent, does not keep place with the fall of pressure.

Fig. 39.



On the diagram (Fig. 40, p. 809), I have represented the relations between the volume, pressure, and temperature, of say ten cubic feet of air at 40° Fahr. or 500° absolute, and at one atmosphere absolute pressure, that is, at the ordinary pressure which surrounds us. The base line represents absolute zero of temperature, and forms the abscissa of the curves.

The vertical lines represent absolute temperatures. The diagonal line, A, drawn from the point where 500° and one atmosphere intersect, to 5,000° at ten atmospheres, represents the increase of temperature required to

produce any given pressure, and is the graphic representation of the equation—

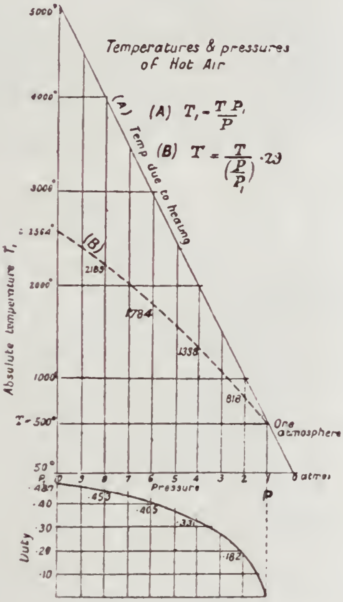
$$T_1 = \frac{T\ P_1}{P}$$

The curved dotted line, B, defines the temperatures to which the air will fall when expanding from any given pressure down to one atmosphere while doing external work. The equation from which these temperatures are calculated is—

$$T_1 = \frac{T}{\left(\frac{P}{P_1}\right)^{\cdot 29}}$$

If these calculations are correct, then the work done in expanding must correspond with

FIG. 40.



the energy latent in the number of units of heat which have disappeared. Take the case where, by heating the air to 2,000°, a pressure of four atmospheres is attained. On expanding and doing work, the temperature will fall 662°, or down to 1,338° absolute. The weight of ten cubic feet of air at 500° and one atmosphere is ·7944 lbs.; hence the energy which has been changed into motion is = 662° × ·7944 lbs. × ·169 × 772J = 68,611 foot-pounds.

The work done in expanding along the adiabatic curve is—

$$= \frac{10\text{ c. ft.} \times 2{,}116\cdot 8\text{ lbs.} \times 4\text{ at.}}{\cdot 408}\left\{1 - \left(\tfrac{1}{4}\right)^{\cdot 29}\right\} = \cdot 68{\cdot}693\text{ foot lbs.}$$

The value 2116·8 lbs. is the pressure of one atmosphere in pounds per square foot. The two results are practically identical, and hence, because the energy in the air is proportional to its temperature, the triangle bounded by the diagonal line, A, will represent the total potential energy of the air at various temperatures and pressures, while the curve, B, shows how much is capable of being rendered kinetic; the ratio, in any ordinate, of the piece between the dotted and the full lines to its total length represents the proportion of heat which can be utilised, and is in effect Carnot's function.

$$\frac{T - t}{T.}$$

The curve beneath the upper figure indicates how rapidly the possible duty diminishes with the decrease of temperature. At four atmospheres the duty can only be 33 per cent., yet under these disadvantageous circumstances a horse-power could, theoretically, be produced for a little more than half a pound of coke per hour.

Referring to the fuel table, you see that coke yields 13,640 units of heat. By suitable arrangements, it can be used to heat air so that the waste products shall escape at about 800° absolute; taking 4,000° as the maximum temperature of the fire, we may expect to realise $\frac{4{,}000^\circ - 800^\circ}{4{,}000^\circ} = \cdot 80$, and, therefore, counting from absolute zero, the available heat will be—(13,640 + 82) × ·8 = 10,978 units.

The air has been heated from 500° to 2,000° absorbing 1,500° × ·7,944 lbs. × ·169 = 201·4 units at the expense of $\frac{201\cdot 4}{10{,}978} = 0\cdot 0184$ lbs. of coke. If the work done by this heat be performed in one minute, it would indicate

$$\frac{68{,}693\text{ foot-pounds}}{33{,}000\text{ foot-pounds}} = 2\cdot 08\text{ horse-power.}$$

The coke consumed per hour would be ·0184 × 60 = 1,104 lbs., and, therefore, the coke consumed per horse-power per hour would be

$$\frac{1\cdot 104\text{ lbs.}}{2\cdot 08\text{ h.p.}} = \cdot 53\text{ lbs.}$$

Again, in this particular case, out of the total 2000°, only 662° have been utilised, there remains 838° available before the exhausted air sinks in temperature to that of the surrounding atmosphere. Can no use be made of this heat? An answer was given to this question by Stirling, at the beginning of this century, when he invented the regenerator, which has

since become widely known in connection with other heat appliances. In hot-air engines the regenerator consists of a number of metal plates, tubes, or sheets of gauze, through which the air passes to and fro; the hot air, in passing through, heats the metal, and the cold air, in returning, is, in its turn, heated by the hot plates, the zone of heat oscillating backwards and forwards with the air.

One of the most successful of the hot-air engines is known as the Rider engine; it is manufactured by Messrs. Hayward, Tyler, and Co., to whom I am indebted for the diagram (Fig. 39, p. 808) on the wall, and for this working model. The engine consists of two plungers, C and D, coupled by means of connecting rods to cranks keyed at right angles to each other on a crank shaft common to both; one plunger, D, called the power plunger, works in a cylinder kept permanently hot by means of a fire, while the other, C, called the compression plunger, works in a cylinder surrounded by a water-jacket. The two cylinders are connected by a wide passage, H, fitted with plates, and constituting the regenerator. There is no change of air in this engine, but the relative motions of the two plungers cause a constant variation in volume and interchange of air between the two cylinders, the increasing volume on the forward stroke synchronizes with an increase of the heating power, because most of the air is in the hot cylinder, while the decreasing volume in the "in" stroke is provided for by the preponderance of cooling power, because most of the air is in the cold, water-jacketed cylinder. The power plunger, D, has the lead of the compression plunger by a quarter of a revolution. Suppose it to have completed half its upward stroke, as on the diagram, the compression plunger being right down, most of the air, considerably compressed, is on the hot side and is being rapidly heated and expanded. The consequent pressure impels the power plunger, D, outward, and, being transmitted through the regenerator, H, acts on the compression plunger, C, whose crank has just turned its bottom centre; both plungers now move upward and drive the crank shaft. By the time the power plunger, D, has reached the top of its stroke, a considerable volume of air has passed through the regenerator, been cooled by it, and filled half the compression cylinder, C, where its temperature is further lowered by the water jacket, E. The momentum of the fly-wheel, aided by the pressure in the compression cylinder, C, now carries the power plunger down against the pressure, but by so doing reduces the volume of air exposed to the fire, and increases that subjected to the cooling influence, so that the balance is against the fire.

By the time the power plunger, D, has descended half its stroke, the compression plunger also begins to descend, and to compress the cold air under it and, drive it backwards through the regenerator, H, from which it takes up the heat into the power cylinder, D, where it gets further warmed, till the power plunger again begins to ascend, and attains the half-stroke, so completing the cycle. The supply of air, to make up for leakage, is derived from a small inlet pipe, L, attached to the bottom of the compression cylinder, and fitted with an automatic valve opening inwards. At the turn of the stroke, if there is any deficiency of air, a partial vacuum is formed, which causes a fresh supply to rush in. There are no distributing valves in this engine, and each plunger works through a leather-packed gland, K, which, in the case of the power plunger, is kept cool by a water-collar immediately under it.

The power cylinder is surrounded, for about half its lower length, by an iron jacket, F, around which the fire plays, the air passes backwards and forwards through the annular space between the cylinder and the jacket, and by that means is not only heated itself, but prevents an excess of heat reaching the cylinder. The regenerator is filled with cast-iron plates about $\frac{1}{8}$ inch thick, placed $\frac{1}{32}$ inch apart. The speed varies from 100 to 140 revolutions per minute. I have been unable to obtain any satisfactory data as to temperature, except that the air is heated to the dull-red heat of cast-iron, which may be taken at 1000° Fahr. The water-jacket, as in the gas-engine, carries off a good deal of heat, which is, therefore, incapable of being converted into useful work. There are a great variety of air-engines, and though extremely useful for small powers, the whole class is not of sufficient importance to claim more of our attention.

Compressed Air Refrigerating Machines. (Figs. 41, 42.)

In the compressed air refrigerating machines we have an interesting example, first, of the conversion of heat into work through the agency of steam; next, the development of heat by the energy so obtained being employed to compress air; and finally, the absorption of heat by the compressed air being made to

do work in its turn. Through the kindness of Mr. Hesketh, the senior representative of the old house of J. & E. Hall, of Dartford, I am enabled to exhibit the drawings of one of their refrigerating engines, to which three gold medals were awarded at the Health Exhibition.

The machine consists of three cylinders, fitted with metallic pistons placed side by side,

FIG. 41.

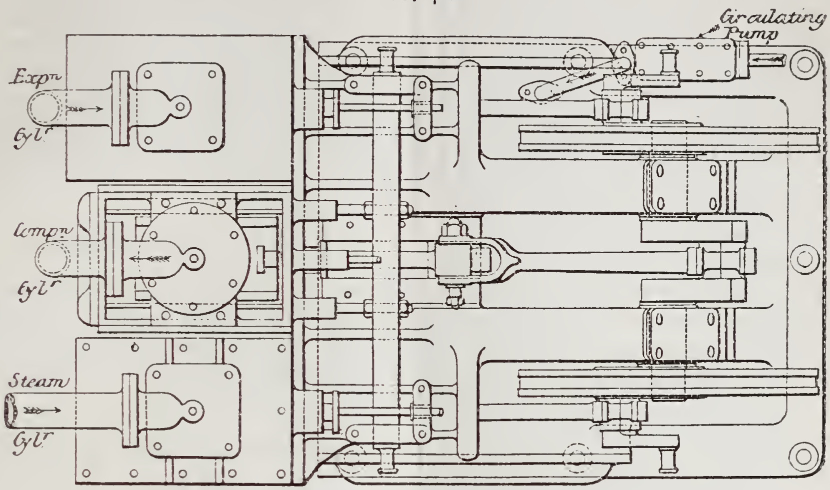
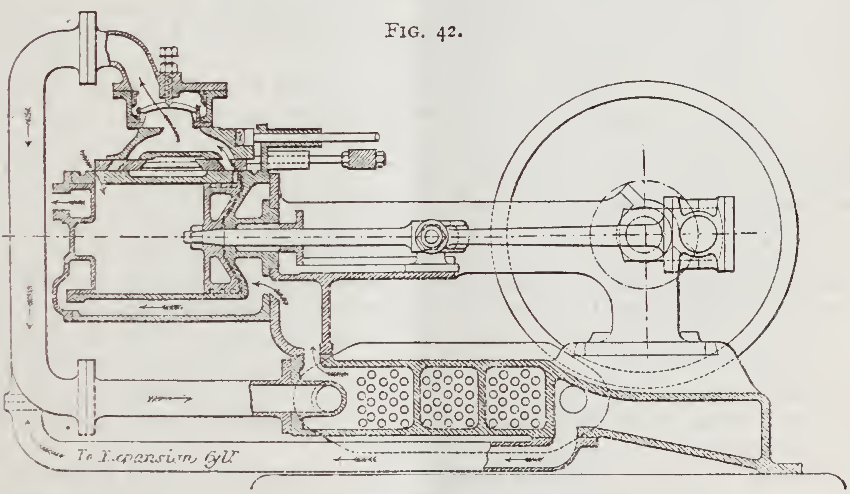
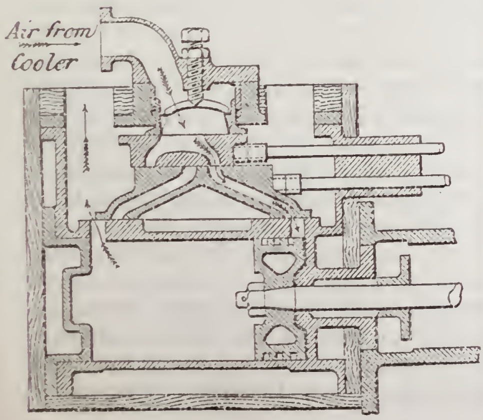


FIG. 42.





and connected by a crank-shaft, common to all, by means of piston-rods, crossheads with slipper guides, and conecting-rods, in the manner common with ordinary horizontal engines. The same crank-shaft drives a water-circulating pump, and beneath the frame which carries the whole mechanism is a tubular refrigerator. The lower cylinder in the diagram is of the kind ordinarily made for steam-engines, and may be constructed with expansion valves, steam-jacket, and all other accessories suitable for a steam-engine of the best construction. The power developed in this cylinder is

transmitted through to the crank-shaft, by an overhung crank, to an intermediate crank, which actuates the piston of the middle, or air-compressing cylinder, which is water-jacketed, and fitted with double-slide valves, of peculiar construction and proportions, through which air is drawn in from the outside atmospere and delivered, compressed to about 45 pounds per square inch, and at a temperature of about 250° to the tubular refrigerator. The hot air circulates through a number of metal tubes, round the outsides of which passes a current of water supplied by the circulating pump, actuated by the upper end of the crank shaft. The water rises about 10° in temperature, and carries off, in the form of heat, a portion of the energy of the steam-engine. The compressed air, reduced to nearly the normal temperature, and at a pressure of 45lbs. per square inch, next enters the upper cylinder on the diagram, through double-slide valves, also of special construction, and is made to expand, doing work upon the piston, and therefore its temperature falls in proportion to the amount of energy communicated to the crank-shaft, which energy is applied to reduce the work to be done by the steam. The temperature of the air is reduced by this means to as much as 130° below the freezing point. In some cases, instead of drawing air into the compression cylinder from the atmosphere, it is drawn from the refrigerated chambers, and is made to pass over a number of tubes containing the compressed air, which is thus cooled to a still lower temperature than was effected by the cooling water, the result being that a relatively lower temperature is obtained after expansion. Simple as the process appears to be, yet, to obtain the best results, great nicety is required in the proportions of the cylinders, in the extent to which the air is compressed, the degree to which the air is expanded, and in the practical details of the valve gear, which are especially important with respect to the difficulties attendant upon the formation of snow and ice derived from the freezing of the moisture always contained in the air. It is the successful treatment of these details which makes the difference between an economical and trustworthy machine and a wasteful or uncertain one. When applied to refrigerate the holds of vessels engaged in the dead meat trade, the money value depending on the efficiency and trustworthiness of a machine is very large.

Setting aside friction, the power necessary to drive the circulating pump, and the heat represented by radiation and conduction, the useful work done by the steam is measured by the quantity of heat carried off by the water circulating round the cooling tubes, and the compression cylinder. The theoretical amount of cooling is easily determined.

The air under an absolute pressure of four atmospheres, and at a temperature a little above that of the surrounding atmosphere, say at 60°, is expanded along the adiabatic curve to one atmosphere, the absolute temperature at the end of the operation will therefore be—

$$\frac{520^\circ}{\left(\frac{4}{1}\right)^{\cdot 29}} = 348^\circ \text{ absolute,}$$

which is 144° below the freezing point, instead of the 130° attained in practice. The air in expanding absorbs a certain amount of heat from the cylinder, and hence the slight discrepancy.

The Steam Boiler. (Figs. 43, 44, 45, 46, 47, 48.)

The last agent in the conversion of heat into useful work which I have to examine is steam, the most important of all, and at the same time the most difficult to investigate exactly. The peculiarity of steam is, that at ordinary temperatures and pressures it is in the liquid form, and is not capable of being used as a working substance. Hence, the application of it must be considered under two heads—first, the conversion of the liquid into an elastic gas; and secondly, the application of the gas so obtained to produce work by means of heat-engines. The two operations, though perfectly distinct, are very often confounded together, and the efficiency of steam-engines is mixed up with that of the fuel and the boiler.

Water, from which steam is derived, is a substance endowed with a higher specific heat than any other body, that is to say, it requires more heat to raise its temperature one degree. The British unit of heat, as I have already explained, is defined to be the quantity of heat which will raise one pound of water at the freezing point 1° Fahr. Steam also has a higher specific heat than most gases, being ·370 at constant volume, and, consequently, the value of y, the ratio of specific heat at constant pressure to that at constant volume is lower, being 1·3, which means that the heat absorbed in the work of expansion bears a smaller proportion to the total heat required to produce a change of temperature,

than is the case with air, for example, of which the true specific heat is only ·169.

The diagram on the wall (Fig. 49, p. 815) represents, in a graphic manner, the properties of steam, for 0 to 500 lbs. pressure per square inch. The base line is divided into equal parts, and represents the absolute pressures, that is to say, the pressures reckoned from a perfect vacuum.

The ordinates bounded by the inner curve represent the temperatures corresponding to the pressures, according to a scale on the left side of the figure. You will notice that the temperatures rise rapidly from absolute vacuum to about 50 lbs. pressure, after which the rise is much more gradual.

The ordinates defined by the upper curve represent, at any given pressure, the total units of heat contained in the steam and the water from which it is derived, the latter taken at the freezing point.

Thus, for example, if we wished to know how many units of heat would have to be communicated to a pound of water, at 50°, to produce steam at 35 lbs. above the atmosphere, we find that, corresponding to 50 lbs., which is the absolute pressure of the steam, we have a

FIG. 43.

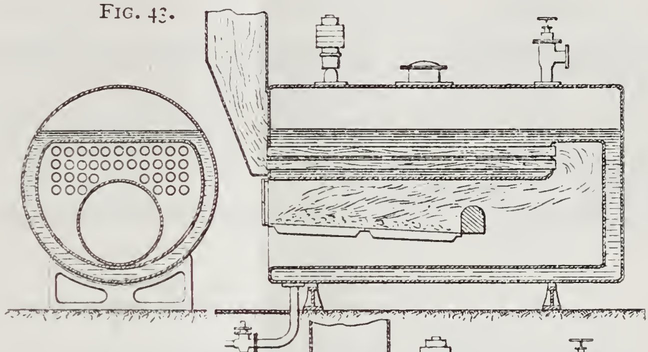
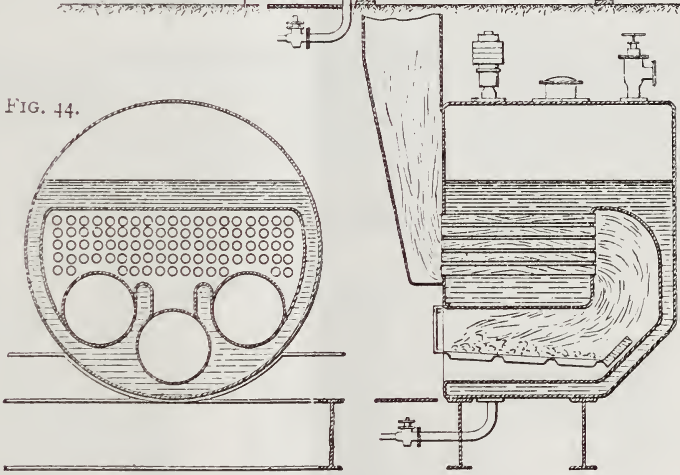


FIG. 44.



temperature of 281°, and 1,116·6 units of heat, reckoned from 32, therefore deducting (50 — 32) = 18°, gives 1,148·6 units, the quantity required.

The apparatus in which water is converted into steam is called a steam boiler or generator, and has now assumed certain well-defined forms.

For portable purposes, such as are required on railways, in agricultural and traction engines, the familiar locomotive type (Fig. 47 p. 814) is invariably adopted. It consists of a rectangular firebox, surrounded by a narrow water space attached to one end of a cylindrical shell, the opposite end of which terminates in a tube plate, which is connected to the fire-box by numerous small tubes, the outer ends of which terminate in a smoke-box, surmounted by a chimney.

For marine purposes, a cylindrical shell (Figs. 43, 44), of which the diameter and length are nearly the same, is fitted with from one to three furnace flues, terminating in a combustion chamber, which is placed close to the rear end of the boiler. This chamber is carried vertically higher than the flues, and is connected over the flues

with the front end by a large number of small tubes, which terminate in a smoke-box, which is attached to the front of the boiler and is surmounted by a chimney.

For stationary purposes (Figs. 45, 46), the shell is generally cylindrical, the length being much greater than the diameter. Each shell contains one or two cylindrical flues, the front ends of which form the furnaces. The flues are commonly traversed by water pipes, and sometimes terminate in clusters of small tubes. The shells are usually set in brickwork, and the products of combustion are carried round before being consigned to the chimney. For small powers, vertical boilers of innumerable forms are employed; and sectional boilers (Fig. 48), composed of small pipes set in ovens, are not uncommon. Of whatever form a boiler may be, it is essential for its efficiency that combustion should take place

Fig. 45.

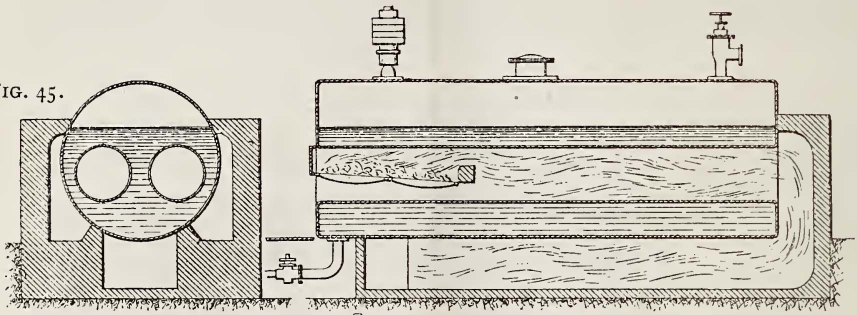


Fig. 46.

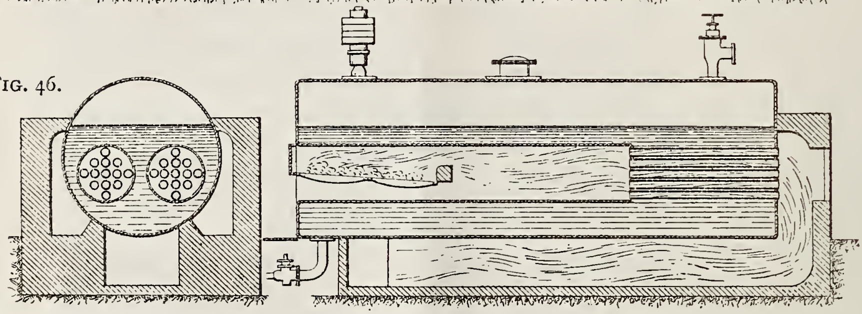
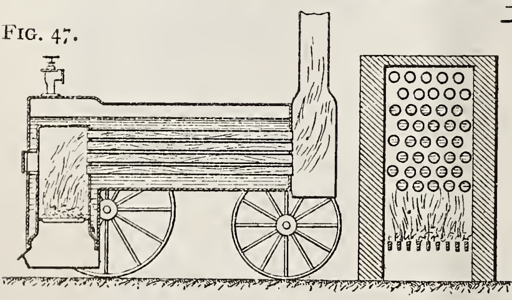


Fig. 47.



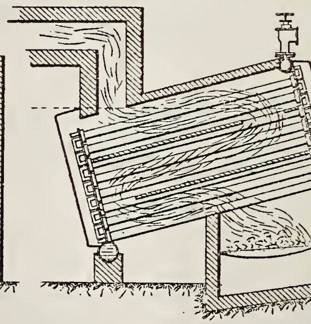


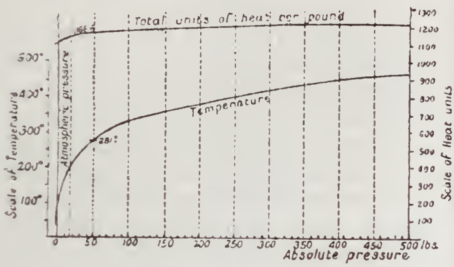
Fig. 48.

in a furnace of large volume, so that the temperature of the flame may be maintained so long as chemical action is proceeding; and that the proportion between the quantity of heat developed in the furnace, and the area of the surface which is destined to absorb the heat, should be such that the products of combustion should be finally rejected at as low a temperature as practicable; and that the fall of temperature should be caused by the useful work being done—that is to say, by the heating of the water fed in, and the conversion of that water, when it has reached the proper temperature, into steam. The useless work is the heating of the rejected products of combustion, and the warming of the air and objects around the boiler, by convection and radiation. When these conditions are observed, the application of Carnot's principles shows that there is very

little scope for the improvement of steam boilers.

By way of illustration, I will exhibit the balance-sheet of a vertical boiler, which was very carefully tested by Sir Frederick Bramwell and Dr. Russell, some seven years ago; and I may here mention that the method of representing the relations between the power available and the manner in which it is expended by means of a balance-sheet, was first employed by Sir Frederick Bramwell with reference to this experiment. The fuel used was coke and wood, the composition, both of the fuel and of

FIG. 49.



the products of combustion, was ascertained by analysis, the quantity of air and feed-water used and their temperature was ascertained, and the loss of heat by radiation was determined, so that, in this remarkable case, we have the means of calculating accurately the values on both sides of the account.

The total potential energy of the fuel with reference to absolute zero, the temperature of the air being 70°, was:—

	Units.
238·25 lbs. fuel × 530° × ·238	30·053
194·46 lbs. carbon × $17\frac{1}{8}$ lbs. air × 530° × ·238 weight and heat of air	420·060
194·46 lbs. × 14,544 *u* combustion of carbon	2,828·200
Total energy	3,278·313
Heat absorbed in evaporating 26·08 lbs. of water in the fuel	29·888
Available energy	3,248·425

Temperature of Furnace.—The whole of the fuel was heated up, and this, together with the heat absorbed in the evaporation of 26·08 lbs. of water in it, lowered the temperature of the fire, and must be deducted from the heat of combustion, leaving thus, 2,798,312 units available from 238·25 pounds of combustible = 11,745 units per pound.

$$\text{Temperature} = \frac{11{,}745^u}{18{\cdot}125 \text{ lbs.} \times {\cdot}238} + 530° = 3{,}253°$$

Temperature of products 700° + 460 = 1,160° absolute

$$\text{Maximum duty} = \frac{3{,}253° - 1{,}160}{3{,}253°} = {\cdot}643$$

$$\text{Maximum work} = 3{,}248{,}425^u \times {\cdot}643 = 2{,}101{,}700^u$$

The useful work done was the evaporation of 1,620 lbs. of water from 60° at 53 lbs. pressure, which represented = 1,855,900 units, the work of displacing the atmosphere by the smoke amounting to 147,720 units, the loss by radiation and conversion was ascertained to be 70,430 units, and the heat left in the ashes is estimated at 1,129 units. Arranging these data in the form of a balance-sheet, we see that only 26,521 units of heat are not accounted for.

Dr. BALANCE-SHEET OF BOILER. *Cr.*

	Units.		Units.	Per cent.
Available heat	2,101,700	1,620 lbs. of water evaporated	1,855,900	88·29
		Displacing atmosphere	147,720	7·03
		Loss by radiation and conversion....	70,430	3·35
		Heat left in ash	1,129	·05
		Unaccounted for	26,521	1·26
	2,101,700		2,101,700	100·

On the right-hand side of the balance-sheet I have placed a column, indicating the percentage which each of the items bears to the total. You cannot but be struck by the large proportion of energy converted into useful work, as much as $88\frac{1}{4}$ per cent., and that the next considerable item is the displacement of the atmosphere, which absorbs 7 per cent. The quantity unaccounted for is only $1\frac{1}{4}$ per cent., which demonstrates the

skill and care brought to bear on this experiment.

I have already, in my fourth lecture, dealt with the properties of fuels and the heat which they are capable of yielding. I regret that the time at my disposal will not permit me to enter more fully into the form, construction, strength, and management of boilers. These matters, if treated fully, would in themselves provide ample materials for more than one lecture.

In discussing the behaviour of air and other gases as agents in the conversion of heat into work, we have assumed that the gaseous condition would be retained down to absolute zero, and that the specific heat and all other properties remained unchanged. This assumption is incorrect, because all gases, like steam, change their physical states under certain conditions of temperature and pressure, but no sensible error has been occasioned by the assumption made, because the working substances remained unchanged within the range of temperature and pressure under consideration. With steam, however, matters are very different. At moderate ranges of temperature and pressure, steam may be either in the liquid or gaseous condition, so that the work done is not proportional to the fall of temperature.

Take the case of a cubic foot of water converted into steam at 65 lbs. absolute pressure, and the corresponding temperature of 298°. Imagine this steam let out of a boiler into the air, the pressure would be reduced to 14·7 lbs., the temperature to 212°, and the volume should be increased to 1,642 cubic feet, if it were not for the heat which must be converted into the work of displacing the atmosphere. Could steam expand along the adiabatic curve the temperature would fall to—

$$\text{temperature} = \frac{758^{\circ}}{\left(\frac{65}{14\cdot7}\right)^{\cdot23}} = 538\cdot5^{\circ} \text{ absolute,}$$

or to 78° on our ordinary scale, but at that temperature steam would not have the tension due to the pressure of the atmosphere, and would, therefore, be unable to penetrate it.

The cause of the fall of temperature is the work done in displacing the air, therefore there must be an equality between the energy necessary to displace the air and that represented by the units of heat absorbed, and as the temperature cannot fall below 212°, the heat required must be obtained from the liquefaction of a portion of the steam. Neglecting the volume of water formed, and supposing x to represent the volume of steam condensed, then $(1{,}642 \text{ c. ft.} - x) \times 2{,}117$ lbs. per square foot = work done in displacing atmosphere.

The temperature of x in condensing falls from 298° to 212°, which from our diagram we find corresponds to 961·8 units of heat per 1 lb. A cube foot of steam at 14·7 lbs. and 212° weighs ·0379 lbs., the volume not condensed falls 86° in temperature, so that the foot-pounds of work done represented by the heat liberated by the condensed steam $= (v - x)\ \cdot0379$ lbs. $\times \cdot305 \times 86^{\circ} + x \times \cdot0379 \times 960\cdot8 \times 772 = \cdot994\ (v - x) + 28{,}098\ x$ these two quantities must be equal, hence—

$$x = \frac{2{,}116 \times 1{,}642}{30{,}214} = 115 \text{ c. ft.}$$

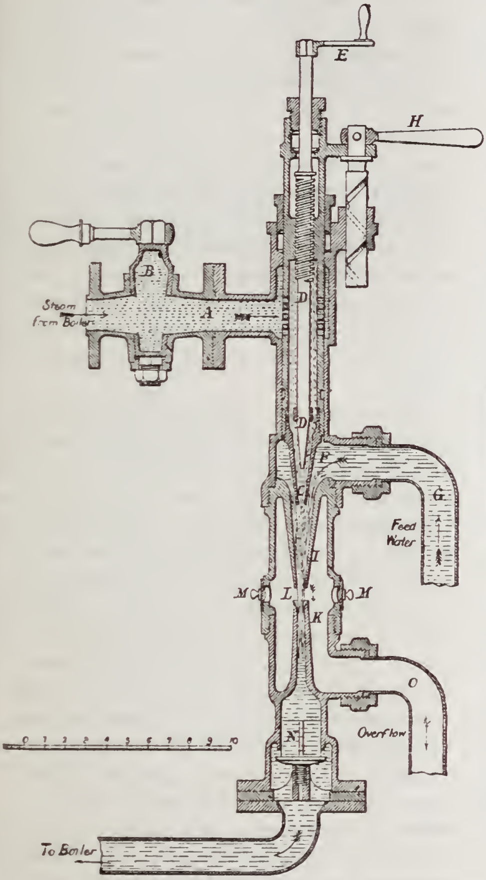
that is to say, 115 cubic feet of steam will be condensed into water in a very finely divided state, interspersed through the escaping steam, and this water can be plainly seen at the mouth of any pipe discharging steam into the air. But the heat necessary for conversion into the work of displacing the air is not taken from the steam alone, but also from any object it may meet with, hence the hand introduced into a jet of high-pressure steam is not scalded, but when steam issues from the spout of a kettle, the circumstances are totally different; the work of displacing the atmosphere is done when the bubbles of steam are formed in the water, and at the expense of the fire, hence the jet of steam maintains its full temperature, and will scald the hand if introduced into it. After the escape of steam from a pipe, it mingles with the surrounding air, and, if the latter be dry and warm, is quickly diffused as invisible vapour, but if cold, and already saturated, is condensed into small globules, which are so numerous, as to form the dense white clouds with which we are so familiar.

The simplest form of steam-engine is the injector (Fig. 50, p. 817). It consists of a mechanical arrangement, by which a jet of steam is made to mingle with a stream of water which it warms in being itself condensed, after which the current of steam and water is delivered to a height, or under a pressure, depending upon the tension of the steam and the proportion of water mingled with it.

The apparatus in its most complete form is illustrated by the diagram. Steam enters through a pipe communicating with a nozzle, the orifice of which can be opened or closed by a taper spindle, which is made adjustable by a screw and hand-wheel. The nozzle itself enters a fixed outer nozzle, also of conoidal

shape, and can be moved longitudinally, so as to vary the area of the annular space between itself and the fixed cone, the latter being connected at its upper end, by a branch pipe, to the water supply. The outer end of the fixed cone terminates in a chamber connected with the atmosphere, and, opposed to it, is a second fixed cone enlarging in the opposite direction. The outer end of this cone is guarded by a self-acting valve opening outwards, and is connected to the delivery

FIG. 50.



pipe. When steam is admitted through its nozzle, the jet issues into the fixed cone; and because this is of larger area, its velocity is reduced, and a certain amount of kinetic energy is rendered potential, just as we saw in the case of diverging pipes. The potential energy takes the form of a reduction of pressure in the water chamber, which at once causes water to flow and surround the steam jet, which is immediately condensed, the water is raised some 60° in temperature, the velocity of the combined stream of condensed steam and water is reduced in proportion to the increase of weight, and enters the second cone, where the velocity is still further gradually reduced to $\frac{1}{15}$ by the diverging pipe, and its potential energy increased to such an extent that the liquid stream will rise to a pressure considerably greater than that of the boiler which supplied the steam. Let us take a particular case. The No. 8 injector has a steam jet 8 milimetres or ·32 inches in diameter, and is the size usually supplied to locomotives. The feed water rises about 60° in temperature. We will assume steam at 100 lbs. absolute pressure, and 328° temperature.

The velocity with which steam, under these conditions, will discharge into the air, is 2,593 feet per second, and the weight delivered will be ·0549 lbs. in the same time. Suppose the feed water at 50°, then the mixture of steam and water will be at 110°, the water rising 60° and the steam falling in temperature 118°. The number of units of heat in the steam is 43·14, consequently, as the increase of the temperature of the feed is brought about at the expense of the fall of sensible heat, and of the latent heat in the steam, therefore, $60^\circ \times x$ lbs. water $= 43\cdot14'' \times \cdot0549$ lbs. $\times \cdot37 \times 218^\circ$ $\therefore x = \cdot793$ lbs., and the weight of the combined steam will be $\cdot793 + \cdot0549 = \cdot848$ lbs. per second, and consequently the velocity will be reduced in the proportion of $\frac{\cdot055}{\cdot848} = \frac{1}{15\cdot4} \times$ 2,593′ or to 168·1 feet per second, and its kinetic energy will be $\frac{\cdot848 \times 168\cdot1^2}{64\cdot4} = 372\cdot4$ foot-pounds.

The stream, endowed with this energy, would occupy much less space than the jet of steam, and therefore the throat of the receiving cone is reduced in diameter, and should, in this case, have an area of ·0116 square inches only. The delivery pipe of the apparatus is about $1\frac{1}{2}''$ diameter, or 151 times the area of the throat, so that the velocity of the water will fall to 1·11 feet per second, and its kinetic energy to ·016 foot-pounds, leaving 372·38 foot-pounds available for overcoming the pressure against which the water has to be discharged. The area of the pipe being 1·76 sq. in., and velocity 1·11′, this energy would be absorbed if the water were discharged under a pressure of 190·6 pounds per square inch, so that an injector is competent to raise water to a much greater height, or deliver it under a greater

pressure, than that of the steam which actuates it.

In this investigation I have made no allowance for friction eddies, and fluid contraction at the orifices; these make an appreciable difference in the calculations, yet results quite as high as I have indicated have been obtained. By reducing the proportion of water to the utmost, its temperature is raised, and its velocity, and therefore the kinetic energy of the combined current is increased to such a point that one boiler has been made to feed another, working under twice the steam pressure.

The apparatus which is commonly called a steam-engine consists essentially of a vessel of cylindrical or spherical form, in which a piston works steam-tight, and receives from a boiler a supply of steam which pushes the piston either backwards and forwards, or round, in a continuous manner.

Steam-engines may be divided into three classes. One, in which a piston reciprocates longitudinally in a cylinder, and receives the impulse of the steam on one side only, or alternately on both sides; second, where the piston reciprocates about the longitudinal axis of the cylinder; and finally, into the whole class of rotary engines, in which the motion of the piston is more or less continuous. The time at my disposal will only permit me to dwell on the first class, which is most common, and by far the most important; but the general principles which I shall explain apply equally to all.

Reciprocating engines may be single or double acting, and have vertical, horizontal, or inclined cylinders; but in all cases the pistons work steam-tight longitudinally in truly bored cylinders, and transmit the energy imparted to them—by means of piston-rods working through packed glands in the cylinder covers—more or less directly to the work which has to be performed. The distribution of steam is managed by valves of various forms, actuated automatically by an endless variety of motions; but in all cases steam is admitted at the commencement of a stroke, allowed to flow in for some portion of it, then shut off and permitted to expand. When the end of the stroke is nearly reached, a passage is opened, by means of which the imprisoned steam is allowed to escape either into the air or into a condenser. In the latter case, it is cooled down by means of a current of water to as low a temperature as possible.

Steam cylinders are sometimes surrounded by a jacket, the space between which and the inner lining is filled with steam at the boiler pressure, and sometimes they are not so constructed, but merely covered, more or less completely, with some non-conducting material.

In double-acting engines the cylinders, at every complete revolution, have each end filled with steam of the temperature due to its pressure, and the quantity of heat imparted to the metal is so great that a uniformity of temperature is kept up, notwithstanding the variation of pressure in the steam.

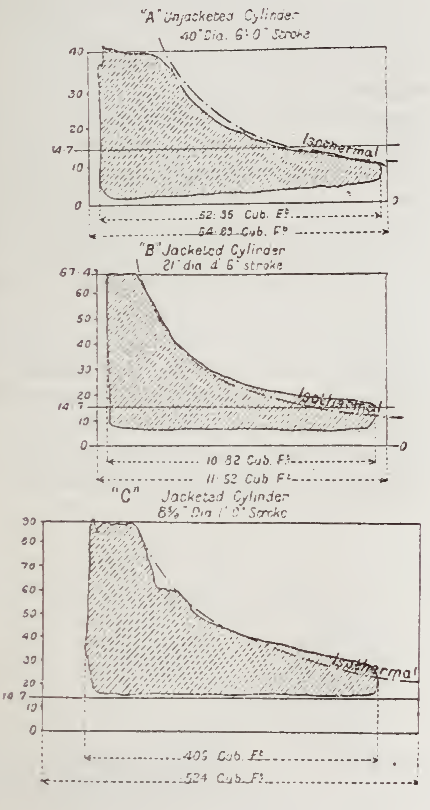
When the cylinders are steam-jacketed, the temperature of the working substance is not only maintained, but the pressure is frequently increased, by the evaporation of water, which may be diffused in the steam or have been carried over from the boiler. For reasons connected with the practical construction of engines, the pistons never sweep through the whole volume of their cylinders; at each end there is a space, representing a small clearance between the surface of the piston, and the cylinder cover added to the volume of the ports and passages, the aggregate usually amounting to from 1″ to 2″ of the length of the stroke.

According to what law do the steam pressures vary with the variation of volume? If the temperature of liquefaction of steam were further removed from the ordinary temperature which surrounds us, and if the working substance could be prevented from receiving heat while expanding, the pressures would vary according to the ordinates of an adiabatic curve; but, as I have already explained, that cannot take place, because the slightest fall in temperature causes a small portion of steam to revert to the liquid state, and the heat so set free raises the rest of the steam in temperature. In addition, because steam is a good radiator and absorber of heat, the hot sides of the cylinder and piston warm it very quickly, so that, in an unjacketed cylinder, the pressures vary very nearly as the ordinates of an isothermal curve.

We must now invoke the aid of the indicator diagram, to tell us what actually takes place inside the cylinder. On the wall is a diagram *A* (Fig. 51, p. 819), taken from a condensing steam-engine, having an unjacketed cylinder, 40 in. diameter, by 6 ft. stroke. The volume swept through by the piston is represented by the length of the diagram, and amounts to 52·35 c. ft., while the total volume, which includes the clearance at each end, is represented

by the vertical lines beyond the figure at each end, and amounts to 54·89 c. ft. The lowest horizontal line represents absolute zero of pressure, that is, absolute vacuum, and the ordinates the absolute pressures per square inch. The horizontal line marked 14·7 represents the standard pressure of the atmosphere. The upper horizontal line represents the initial steam pressure in the cylinder, and the point where the figure suddenly falls away from it indicates the spot where the steam-valve closed, and the steam commenced to

FIG. 51.



expand. At the end of the stroke, the figure drops suddenly again. This marks the point where the valve, communicating with the condenser, opens and allows the imprisoned steam to escape. The lower line of the figure registers the "back pressure," as it is called, that is, the tension of the steam in the condenser, and, finally, the sudden rise of this line indicates the point where steam is again admitted, and the cycle completed. I have dotted in the isothermal curve; you see how closely it follows the curve traced by the indicator; the temperature of the steam, therefore, has not varied, hence the heat converted into work must have been derived from the heat communicated to the metal of the cylinder and piston during the time that steam was entering. This could only take place by the condensation of a small portion of the steam.

Let us give this action a numerical value. We have seen that the work done in expanding along an isothermal curve is = pressure per square foot × volume of agent used × the hyperbolic logarithm of the ratio of the total volume to the volume used, or let P_1 = pressure per foot square, V_1 volume used, V, total volume of cylinder, then work

$$= P_1 V_1 \log^e. \frac{V}{V_1}.$$

But in a steam-engine, the piston is moving and doing work all the time the steam is being admitted, and this work = $P_1 V_1$, therefore the total work will be the sum of the two = $P_1 V_1 \left(1 + \log^e. \frac{V}{V_1}.\right)$, supposing a perfect vacuum to exist; but as this never is the case, and, in non-condensing engines the pressure which opposes the return of the piston is even a little higher than one atmosphere, we must deduct the work done against back pressure. To ascertain this, the mean back pressure must be measured off the diagram, let us call it p per square foot, then the work done will be p V, hence the nett work will be

$$P_1 V_1 \left(1 + \log^e. \frac{V}{V_1}\right) - p V.$$

In the particular case we are dealing with—

$$W = 40·5 \text{ lbs.} \times 144 \text{ sq. in.} \times 13·09 \text{ c.ft.} \times \left(1 + \log. \frac{52·35 \text{ c.ft.}}{13·09 \text{ c.ft.}}\right)$$
$$- 3·8 \text{ lbs.} \times 144 \text{ sq. in.} \times 52·35 \text{ c. ft.} = 153·354 \text{ foot-pounds.}$$

which agrees very closely with the actual area of the diagram, measured either by scale or with a planimeter.

Since the pressures, in expanding, have varied as the ordinates of an isothermal curve, it follows that the temperature of the steam has not altered, and, consequently, none of its heat has been converted into work; but the heat which has been so converted must have been derived from an extra volume of steam, which was condensed by the relatively cold surfaces it came in contact with, which surfaces again give it out as the volume of the steam increased, and so kept up the waste caused by the conversion into work; in other

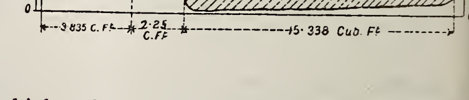
words, the surfaces of the cylinder acted as carriers of heat from the boiler to the expanding gas. We can easily calculate the quantity of steam condensed.

The work done in each stroke we have seen is 153,354 foot-pounds, corresponding to 198·6 units of heat. The total heat of steam at 40·5 lbs. pressure, and 268° temperature is 1,163 units, and as the condensed steam remains at the same temperature, the available heat is $1{,}163^u - (268 - 32) = 927^u$; therefore, the weight of steam condensed to supply the heat converted into work will be $\dfrac{198{\cdot}6^u}{927^u} = {\cdot}214$ lbs.

Now, the total volume of steam let into the cylinder up to the point of cut off, was $\dfrac{54{\cdot}89 \text{ c. ft.}}{4} = 13{\cdot}72$ cubic feet, the weight of which, $= \dfrac{13.72 \text{ c. ft.} \times 62{\cdot}2 \text{ lbs.}}{641 \text{ c. ft.}} = 1{\cdot}329$ lbs., adding to this the weight condensed, we have 1·543 lbs. of steam used per stroke. But of this only ·214 lbs. is converted into work, so that the duty is only $\dfrac{{\cdot}214}{1{\cdot}543} = {\cdot}14$, or 14 per cent. The mean back pressure was 3·8 lbs., and in the condenser the temperature would be that due to the pressure, or $151° = 611°$ absolute, while the initial temperature is 268°, or 728° absolute, so that our agent is working between these temperatures, and hence, according to Carnot's doctrine, the duty could not exceed $\dfrac{728° - 611°}{728°} = 16$ per cent., which differs by only 2 per cent. from the duty derived from estimating the comparative weight of steam required for filling the cylinder, and for actual conversion into work. This difference probably arises from the uncertainty as to the temperature of the exhaust steam in the cylinder. It is sure to be higher than that in the condenser, because the hotter surface of the cylinder and piston would warm it up. If t be the true absolute temperature, then $\dfrac{728° - t°}{728°} = {\cdot}143$ $t° = 624°$; that is, the steam would be 13° hotter than the temperature absolutely necessary to maintain its pressure—which is very likely to be the case.

Fig. 51, diagram *B* (p. 819), is an indicator diagram from a condensing-engine with a vertical cylinder 21 in. diameter by 4 ft. 6 in. stroke the surfaces jacketted all over. The dotted line is the isothermal, and you notice that the true pressure curve rises above it towards the end of the stroke. The same remark applies to diagram *C* (Fig. 51, p. 819), taken from a portable non-condensing engine having a cylinder $5\frac{5}{8}$ in. diameter by one foot stroke, also jacketted all over. Inasmuch as the steam in the jackets is at the same pressure and temperature as that admitted to the cylinders, it follows that the rise of pressure above the isothermal cannot be due to an increase of temperature, but must be caused by the evaporation of water carried over by the steam from the boiler. In these cases the heat converted into work has been derived from the steam in the jackets, transferred by radiation and convection from the metal of the cylinders; the condensed steam withdrawn from the jackets would, therefore, represent the quantity of heat converted into useful work. When the steam pressure becomes considerable, and a large range of expansion is aimed at, a single cylinder becomes so large, and the strains so severe, that it is more convenient to arrange for the steam to expand in two or more cylinders successively. Engines constructed on this plan are called "compound." The cylinder into which the steam first enters is the smallest; it exhausts into a large one, and this again into one still larger, and so on. Diagram *D* (Fig. 52), illustrates the action

FIG. 52.



which takes place. The figure on the left hand has been traced from the high-pressure cylinder of a double cylinder engine. It has a working volume of 3·835 cubic feet, or with clearance, 4·427 cubic feet. 2·75 cubic feet of steam at 78 lbs. absolute pressure were admitted during the down stroke; the upper line indicates the pressures which resulted till the valve was opened to permit the steam to flow into the low-pressure cylinder. This had a

olume of 15·338 cubic feet, or 16·426 cubic eet with clearance.

Between the two cylinders the connecting pipe, valve chest, and clearances have a apacity of 2·25 cubic feet. The two cylinders re coupled, so that the pistons travel simultaneously in the same direction, so that the steam from the top of the high pressure cylinder completes its work in the bottom of the low, during the up stroke. While this is going on, the two cylinders are in communication, and the volume occupied by the steam is constantly altering, the capacity of the small cylinder decreasing, that of the large increasing, the connecting space between remaining constant. The figure on the right hand side is that traced by the indicator with the base line made proportional to the volumes successively occupied by the steam. The dotted line is the isothermal. It follows exactly the expansion curve of the high pressure diagram, and again touches the curve of the low pressure figure at the end of the stroke, but there is a considerable divergence at the commencement of the low pressure stroke, caused partly by the cooling of the steam in traversing the unjacketed connecting passages between the cylinders, and partly by the resistance of friction and eddies in the passages. This loss is, however, ultimately made up by the heat imparted by the steam jackets of the cylinders. In both cylinders there is negative work; in the high pressure it is the reaction to the pressure on the low, and is equal to the total work done in the latter, reduced in the ratio of the volumes of the two cylinders, and in the low pressure it is the resistance of the imperfect vacuum in the condenser.

A practical illustration of the work done by the steam condensed in the jackets, we may find in the case of a pair of pumping-engines at the Lambeth Waterworks, Brixton.

These engines were found to consume 16·8 lbs. of steam per horse-power per hour in the cylinders, and 2·8 lbs. in the jackets. Steam was at 54·4 lbs. pressure, or 69·1 lbs. absolute and 302° temperature.

The total heat of 1 lb. of steam under these conditions is 1,174^u from the freezing-point; hence, as the steam was condensed to water at very little below its own temperature, the heat parted with was 904 u per 1 lb., corresponding to work per minute

$$\frac{2{\cdot}8 \text{ lbs.} \times 904 \text{ lbs.} \times 772^J}{60'} = 32{,}569 \text{ foot-lbs.}$$

which is a little less than a horse-power.

The duty done by 19·6 lbs. of steam per horse power per hour was therefore represented by the 2·8 lbs. condensed $= \frac{2{\cdot}8}{19{\cdot}6} = {\cdot}142.$

The range of temperature could not have been more than 149°, that is, from 302°, the initial temperature of the steam to that of the condenser corresponding to 4 lbs. average back pressure, say, 153°; hence the duty would be, according to Carnot, $= \frac{149°}{762°} = {\cdot}195$, about 5 per cent. more than in my previous estimate, the discrepancy being due, as I have already pointed out, to the uncertainty as to the temperature of the steam in the cylinder on the vacuum side.

The work of pumping out the mixture of condensed steam and water against the atmospheric pressure in condensing engines, and of pumping feed water into the boiler in all engines, should be deducted from the available work indicated by the diagrams.

From the four cases which I have cited, you will see that steam does not differ from air in a hot-air engine, or from the mixture of gases in a gas engine, in being merely the agent of transforming a certain amount of heat imparted to it into useful work. The circumstance that we have to manufacture the agent from its liquid state at great cost is a disadvantage, because we cannot utilise much of the heat so expended, and is also the cause why, in steam-engines, the useful effect obtained necessarily bears so small a proportion to the total energy imparted to the agent in its liquid form.

It is difficult to realise the proposition that the gases used as agents in heat-engines have no influence on the proportion of heat converted into work. The truth is, that their function is similar to that of a train of wheelwork, or of a lever, in transmitting a mechanical effort. A common lever used for the purpose of raising a weight is an agent by means of which a force is caused to perform certain work, but the lever itself has no influence at all on the result. Provided the length of the arms is kept at a constant ratio, the action will not be affected by the lever being short or long, light or heavy, of wood or of iron. There is, however, this difference between the lever and the gaseous agent, namely that the former can be used over and over again, without in any manner deteriorating or changing its nature, consequently its first cost is not of much moment

Ayrton, F.R.S.; Viscount Bury; E. C. Cracknell; Colonel Festing, R.E.; Professor George Forbes, M.A.; Dr. J. Hopkinson; Professor D. E. Hughes; Professor Oliver Lodge, D.Sc.; W. H. Massey; J. Fletcher Moulton, F.R.S.; C. E. Spagnoletti.

JURY J.

Group 14.—*Apparatus, Processes, and Appliances connected with Applied Chemistry and Physics.*

Group 15.—*Gas and other Illuminants.*

Group 17.—*Food, Cookery, and Stimulants.*

Group 28.—*Philosophical Instruments and Apparatus (with the exception of Class* 151, *Group* 28, "*Electrical Apparatus*").

Professor W. Odling, F.R.S. (Chairman); Professor Guthrie (Vice-Chairman); Boverton Redwood, F.C.S. (Reporter); W. Proctor Baker; H. J. Chaney; W. H. Christie, M.A., F.R.S.; W. J. Dibdin; Harold Dixon, M.A.; J. Emerson Dowson; Surgeon-Major Theodore Duka, M.D.; Professor G. Carey-Foster, F.R.S.; Major G. S. Sewell-Gana; J. Norman Lockyer, F.R.S.; Dr. L. Loewenherz; H. McLeod, F.R.S.; W. H. Perkin, Ph.D., F.R.S.; Sir. H. E. Roscoe, F.R.S.; C. Meymott Tidy; Walter Weldon, F.R.S.

JURY K.

Group 19.—*Jewellery.*

Group 22.—*Furniture and Accessories; Fancy Goods.*

Group 23.—*Pottery and Glass.*

Group 24.—*Cutlery, Ironmongery, &c.*

Lord Alfred S. Churchill (Chairman); Sir George Birdwood (Vice-Chairman); E. Macrory (Reporter); R. W. Binns; R. Brudenell Carter; Professor A. H. Church, M.A.; Colonel Shadwell Clerke; Alfred Copeland; Henry Harrison; George Lambert, F.S.A.; Leopold Pam; Alfred Phillips; F. B. Thomas; Thomas Wardle; Godfrey Wedgwood; W. Woodall, M.P.

JURY L.

Group 20.—*Leather, &c.*

Group 21.—*India-rubber and Gutta-percha, &c.*

W. L. Jackson, M.P. (Chairman); T. E. Blair; T. Bolas; P. B. Cow; W. Dent; Sparke Evans; Benjamin Nickels; Thomas Palmer, B.Sc.

JURY M.

Group 8.—*Aeronautics.*

Group 25.—*Fire-arms; Military Weapons and Equipment; Explosives.*

Colonel Sir Charles Nugent, R.E., K.C.B. (Chairman); Admiral Boys (Vice-Chairman); Captain W. H. Hall, R.N. (Reporter); Colonel H. Arbuthnot, R.A.; Lieutenant-Colonel Bond; Sir William Crossman, R.E., K.C.M.G.; Earl de Grey; A. Dupré, M.D., F.R.S.; Lieutenant-Colonel Fairfax Ellis, R.A.; Commander Gallwey, R.N.; Baron von Linden; Captain Linden; Colonel Majendie, C.B.; Lieutenant-Colonel W. H. Noble, R.A.; Stewar Pixley; Major M. S. Sale, R.E.; Major Templer.

JURY N.

Group 26.—*Paper, Printing, Bookbinding, Stationery, &c.*

C. M. Kennedy, C.B. (Chairman); W. Blades; Richard Clay; Edward Alfred Cowper; J. S. Hodson; Hugo Müller, Ph.D., F.R.S.; Robert Cradock Nichols; J. L. Clifford-Smith; Henry Spicer.

JURY O.

Group 27.—*Clocks, Watches, and other Timekeepers.*

J. Norman Lockyer, F.R.S. (Chairman); G. S. Criswick, F.R.A.S.; Henry Dent Gardner; D. Glasgow; Professor T. A. Hearson, R.N.; Thomas Mercer; Edward Rigg, M.A.; J. Rotherham; A. Stroh; J. Tripplin.

JURY P.

Group 29.—*Photography.*

Warren de la Rue, D.C.L., F.R.S. (Chairman) Captain Abney, R.E., F.R.S. (Vice-Chairman); Colonel Stuart Wortley (Reporter); T. Bolas; W. B. Bolton; Hugh W. Diamond, M.D., F.S.A., W. F. Donkin; John Spiller, F.C.S.

JURY Q.

Group 30.—*Education Apparatus.*

Group 31.—*Toys, Sports, &c.*

Col. Festing, R.E. (Chairman); Major Anstruther, R.A.; G. C. T. Bartley; T. William Erle; J. G. Fitch; Major G. S. Sewell-Gana; Philip Magnus; Julian Marshall.

The Prince of Wales and the Duke of Edinburgh privately visited the historic music loan collection in the galleries and rooms of the Royal Albert-hall on Tuesday, 2nd inst. Their Royal Highnesses were received by Sir Frederick Bramwell, Chairman of the Executive Council, the Marquis of Hamilton, Chairman of the Music Committee, and other members of the Executive Council and Music Committee. Their Royal Highnesses made an inspection of the various objects in the collection, and expressed themselves highly pleased with the results of the labours of the Music Committee. The collection is now open to the public.

The number of visitors to this Exhibition for the week ending Tuesday, 2nd inst., was 136,704. Total since the opening, 533,017.

THE FUR INDUSTRIES OF ALASKA.

In the final report on the tenth census of the United States, an interesting account of the population, industries, and resources of Alaska is given, and from this it appears that of the various industries of Alaska, the fur trade is the only one that calls for any particular mention. The sea otter is a very shy

and sensitive animal, and does not congregate in any great numbers, rarely setting foot upon the shore, and then only in some secluded retreat. It is found sixty and eighty miles from land, singly and in pairs, and even females and their young are frequently seen floating about at that distance. In former times, the Aleutian hunters prepared themselves for sea otter expeditions, by fasting, bathing, and other ceremonies. The sea otter was believed to possess a very strong aversion to the female sex, and the hunter was obliged to himself prepare the garments he was to wear, or at least to wash with his own hands such of his clothes as had been made by women, and on his return the hunting clothes were thrown into the sea, as it was believed that the sea otters would find them and come to the conclusion that their late persecutor must be drowned, and that there was no danger. With the spread of the Christian religion among the sea otter hunters, most of these superstitious ceremonies were abolished. The mode of hunting has not essentially changed since the earliest times. A few privileged white men, located in the district of Ounga, employ firearms, but the great body of Aleutian hunters still retain the spear, and in a few instances the bow and arrow. The sea otter is always hunted by parties of from four to twenty canoes, each manned by two hunters. From their village the hunters proceed to some lonely coast near the hunting ground, either in their canoes or by schooners and sloops belonging to the trading firms. The tents of the party are pitched in some spot not visible from the sea, and the hunters patiently settle down to await the first favourable day, only a smooth sea permitting the hunting of sea otter with any prospect of success. In the inhospitable climate of Alaska, weeks and months sometimes pass before the hunters are enabled to try their skill. When the day arrives the hunters embark, fully equipped, and when the beach is left behind, perfect silence is maintained, the *peredovchik*, or leader, assumes command, and at a signal from him the boats start out in a semi-circle, from fifty to a hundred yards distant from each other. As soon as the hunter sees an otter, he lifts his paddle as a signal, and then points it in the direction taken by the animal, and the scattered boats at once close in a wide circle round the spot indicated. As soon as the otter comes up within spear's throw, one of the hunters lodges a spear-head in the animal, which immediately dives. An inflated bladder is attached to the shaft, thus preventing the otter from diving to a very great depth. It comes up again to the surface and is killed, the body being taken into the canoe, and the hunt continues if the weather remains favourable. On the return of the party, each animal killed is inspected by the chief, in the presence of all the hunters, and its ownership ascertained by the spear-head that caused the mortal wound, each weapon being duly marked. The skins of the slain animals are at once removed, labelled, and classified according to quality, by the agents of the trading firms, and carefully stored for shipment. It frequently happens that a whole day passes by without a single sea otter being sighted, but the Aleutian hunters have great patience, and do not leave a place once selected without killing some otters, be the delay ever so long. On the principal grounds of the present time, the island of Sannakh, and the neighbourhood of Belkovsky, the hunting parties seldom remain over four or five months without securing sea otters in sufficient numbers to warrant their return. As soon as the result of a day's hunt has been ascertained, the chief, or leader, reminds the hunters of their duty towards the church, and with their unanimous consent some skin, generally of a small animal, is selected as a donation to the priest, all contributing to reimburse the owner. The killing of fur seals is accomplished entirely on land, and the able-bodied Aleuts who are settled upon the two islands of Saint Paul and Saint George, are, by the terms of the agreement between themselves and the lessees, the only individuals permitted to kill and skin the seals. For this labour they are paid at the rate of 1s. 8d. per animal. The work connected with the killing of the annual quota of fur seals may be divided into two distinct features, the separation of the seals of a certain age and size from the main body, and their removal to the killing ground, and the selection among the select, and killing and skinning the same. It is the habit of the young male seals, up to the age of four years, to lie near the sea shore, and the experienced natives manage to crawl in between them and the sea and gradually drive them inland, in divisions of from 2,000 to 3,000. It is unsafe to drive the seals more than five or six miles during any one day, as they easily become over-heated, and the skins are thereby injured. When night comes on the driving ceases, and sentries are posted round each division to prevent the animals from straying during the night, occasional whistling being sufficient to keep them together. In the morning, if the weather be favourable, the driving is continued until the killing ground is reached, where the victims are allowed to rest over night under guard, and finally, as early as possible in the morning, the sealers appear with their clubs, when again small parties of twenty or thirty seals are separated from their fellows, surrounded by the sealers, and the slaughter commences. Even at this last moment another selection is made, and any animal appearing to the eye of the Aleut to be either below or above the specified age, is left untouched, and allowed to go on its way to the shore. The men with clubs proceed from one group to another, immediately followed by the men with knives, who stab each stunned seal to the heart to ensure its immediate death. These men are in turn followed by the skinners, who with great rapidity divest the bodies of their valuable covering, leaving, however, the head and flippers intact. A few paces behind the skinners come carts, drawn by

mules, into which the skins are rapidly thrown and carried away. The wives and daughters of the sealers linger in the rear of the death-dealing column, taking away the blubber, which they carry on their heads, the oil dripping down their faces and over their garments. The skins, yet warm from the body, are discharged into capacious salt-houses, and salted down for the time being. This treatment is continued for some time, and after the application of heavy pressure, they are finally tied into bundles containing two skins, securely strapped, and are then ready for shipment. The following is the process by which these skins are prepared and dressed in New York. When the skins are received by the furriers, in the salt, the latter is washed off, and the fat removed from the inside with a knife, great care being taken that no cuts or uneven places are made in the pelt. The skins are next thoroughly cleansed by being stretched upon beams and dried. After the drying process, they are soaked in water, and thoroughly washed with soap. After this the fur is dried again, the pelt being kept moist, and the workmen pull out the long hair with the assistance of a dull knife. This operation, a very delicate one, is repeated several times until nothing but the soft fur remains. The skins are then dried again and moistened on the pelt side, and shaved until a fine even surface is obtained. Then follows the process, a slow and tedious one, of working, drying, and softening the skins by treading them with bare feet, in a hogshead, with fine sawdust to absorb the grease. In dyeing, the liquid is put on with a brush, the points of the standing fur being carefully covered. The skin is then pulled so as to make the points touch each other for some little time and partially dried. The dry dye is removed and another coat applied, and the same process is repeated a number of times. A few of the coats of dye are put on heavily pressed down to the edge of the fur, from eight to twelve coats producing a good colour. The skins are then washed again, and cleansed with sawdust.

Correspondence.

VENTILATION OF SEWERS.

Mr. Buchan misapprehends my argument. My plan does not provide the poison, but Mr. Buchan's plans increases it. My plan prevents its formation. If it be accidentally formed, it is impossible for it to find its way into the house except by gross negligence on the part of someone. If it be formed, it will be discharged above the level of the house top, and immensely diluted before it comes in contact with human life. Mr. Buchan's plan compels its discharge at a low level, viz., at the level of the street, or else introduces an impossible series of ventilating shafts for the public sewer. Sewer gases discharged at the street level will be much more concentrated than those which escape in the upper regions of the air.

Mr. Buchan states that "we have to deal with things as they are." This is agreed to. But we are not called upon to allow them to remain so, when it is certain that they are wrong. A man has no right to fold his hands and say "my interceptor makes me safe; I don't care what may happen to those who walk along the street." It is our duty as citizens to call upon the local authorities so to construct the sewers that they shall not manufacture sewer gas; and it is our duty also so to construct our own house drains that they shall not retain any sewage in any part of their course. I believe myself that much more serious mischief arises from defective house drains than from defective sewers. My plan diminishes the danger from both.

Mr. Buchan seems to be surprised at the statement "that fresh sewage is not dangerous to anybody." If he will read my paper in the Transactions of the International Medical Congress in London, in 1881, he will see that I have fully proved that fact. Let him go to the fever hospitals; he will not find any danger to those about the patients from their excreta, if cleanliness is perfect. It is only after fermentation has taken place in fæcal evacuations that they become sources of danger to those who have to do with fever or even cholera cases.

I am sorry to find that Mr. Buchan has not realised the fact that dilution leads to destruction. The mischiefs which arise from concentration and from overcrowding can only be dispersed and then destroyed in this way. The poison which is discharged from the chimney tops of a great city is a thousand times more poisonous than sewer air, but it is completely destroyed by dilution, an action which is evolved in nature's laboratory without man's assistance. So also is the poison which produces typhus fever, scarlatina, and even small-pox. Dilution, with its consequences, destroys it. If it were not so, if the germs which produce diseases of this kind were not demolished almost as fast as they are formed, the immense multiplication which takes place around every case would soon utterly destroy the human race. We have the application of the remedy in our own hands if we like to use it. It is by means of ventilation; by that means which involves continuous movement. We have in the atmosphere a similar power to that which exists in water, viz., a self-cleansing power if fresh air be admitted. If this be allowed full play, it keeps our atmosphere in a remarkable state of purity and perfection.

Mr. Buchan surely cannot suppose that it is necessary to allow sewer air to get inside a house because a current is established through the house service, in the place of that stagnation which I know to be dangerous. Mr. Buchan's plan introduces a danger.

Interceptors have had to be abandoned in a great number of instances from this reason; anything which leads to impeded circulation in sewers is bad work.

As to Mr. Buchan's last paragraph concerning rats, I can only say that if house drains are so made that rats can get into the houses from the sewers they must be curiously made indeed, and God help the people who live in them. I do not see that Mr. Buchan's interceptor can keep them out any more than the water trap in the w.c.

ALFRED CARPENTER, M.D.

Croydon, May 20, 1885.

[This correspondence will now cease].

SEWAGE TREATMENT.

The paper read by Dr. Thresh, on the 14th May, is an interesting record of the treatment of the sewage of Buxton, by means of a natural chalybeate water containing ferrous sulphate and aluminic sulphate. The action of these precipitants upon sewage I made the subject of a series of experiments some years ago, and I found that the addition of a proto-sulphate of iron to crude sulphate of alumina intensified the action of the alumina, and gave such excellent results in purifying sewage that it led to the process being patented and successfully employed in several towns on a large scale. Buxton is fortunate in the existence of its stream of water, charged with the necessary chemicals for producing sewage precipitation, but towns not similarly situated can adopt the artificial combination of chemicals I refer to, and obtain equally good and even better results. I described my process in a paper on "Sewage Disposal," which I read before the Surveyors' Institution at the beginning of this year, but a still more complete description of it was given to the Parliamentary Committee last Session, which had before it the scheme of the Lower Thames Valley Main Sewerage Board which had adopted the process.

HENRY ROBINSON, M.Inst. C.E.

7, Westminster-chambers,
London, S.W., 26th May, 1885.

Mr. Arthur Shippey writes, in reference to Sir Frederick Abel's remarks on the utilisation of the waste gases from our coal fields (see *ante* p. 782), to draw attention to his patent for a "method of collecting virgin coal gas or carburetted hydrogen, &c." (Specification A.D., 1884, No. 1,752.)

Notes on Books.

A MANUAL OF HEALTH SCIENCE, adapted for use in Schools and Colleges, and suited to the requirements of Students preparing for the Examinations in Hygiene of the Science and Art Department, &c. By Andrew Wilson. London: Longmans. 1885.

The above title sufficiently expresses the objec which the author has in view in the production of this little book. After dealing with the conditions of health and the functions of the body, Mr. Wilson proceeds to discuss various points connected with food, diet and cooking, water and beverages, &c. Subsequent chapters are devoted to the air we breathe, ventilation, removal of waste matters, local conditions of health, shelter and warming, personal health, ambulance work, and infectious diseases. A series of questions on the subjects of the manual is added.

ART WORK MANUALS. Edited by Charles G. Leland. Nos. 1, 3-12, New York. London: Trübner and Co.

Mr. Leland, the editor of this series of manuals, is also the Director of the Public Art Schools of Philadelphia, and his object is to carry out the same mode of treatment in these manuals as he has in the schools, that is, to utilise drawing by applying it to the practise of the minor arts. No. 1 is devoted to Ceramic Painting; No. 3, to Wood-carving; Nos. 4 and 7, to Art Needlework; No. 5, to Leatherwork; No. 6, to Decorative Oil Painting; No. 8, to *Repoussé* Work; No. 9, to Stencilling; No. 10, to Drawing and Decorative Design; No. 11, to *Papier Maché*; No. 12, to Modelling in Clay. Each number contains a series of illustrations. It will be remembered that Mr. Leland read a paper before the Society of Arts, on "Education in Industrial Arts," on February 4 last.

RUSSIAN CENTRAL ASIA, INCLUDING KULDJA, BOKHARA, KHIVA, AND MERV. By Henry Lansdell, D.D. London: Sampson Low, Marston, Searle, and Rivington. 2 vols., 8vo.

Dr. Lansdell, author of "Through Siberia" (previously noticed in the *Journal*, see vol. xxx., p. 347), has described in these new volumes of travels a journey of 11,000 miles (5,000 by water, and 3,700 on wheels, horses, or camels) through Western Siberia to Kuldja, thence through Russian Turkistan and the Kirghese Steppes to Tashkand, Khokand, and Samarkand, crossing into Bokhara. The author travelled through the Khanate as guest of the Emir, floated 500 miles down the Oxus to Khiva, and then continued by a new route across the land of the Turkomans and north of Merv to Krasnovolsk. He here describes some hundreds of miles of country not previously visited by an English author. The author has paid special attention to the accurate description of the fauna and flora of the countries he passed through, and in this department be has been assisted by authorities on the several subjects. The book is fully illustrated, and contains folding maps of the district travelled. There are three appendixes. A is devoted to the fauna, B to the flora, and C contains a list of 700 works on Russian Central Asia, chronologically and topically arranged, with an alphabetical list of authors.

General Notes.

Fisheries of Italy.—The Minister of Agriculture, with a view of obtaining information and statistics for the publication of a report relating to the sea fisheries of Italy, has issued a circular to the authorities on the coast, in which they are requested to answer the following questions:—1. As to the present condition of the fishing industry in each particular district. 2. The principal varieties of fish taken. 3. The approximate value of the fish caught annually. 4. Whether any portion of the fish taken are exported, and to what countries. 5. The means that should be adopted in order to encourage pisciculture, and the obstacles that stand in the way of its development. 6. What are the particular systems or methods for fishing that it would be advisable to encourage, taking into consideration local conditions, and what are the difficulties to be removed in order to adopt them. 7. The condition of the fishing population, and whether it has improved since 1878; are any provident institutions in existence, and in what manner could they be encouraged.

Berlin Exhibition, 1888.—The discussion as to the nature of the Berlin Exhibition of 1888 has resulted in the decision that it will be strictly national, the representatives of Berlin commerce and industry having arrived at this resolution at a meeting held on May 20th. Amongst the reasons urged in favour of 1888 was the supposition that many exhibitors at the Paris display of 1889 would visit Berlin the year before, and thus see what Germany was doing in various branches of manufacture.

Paris Exhibition, 1889.—The Parisians are actively engaged in arranging the preliminaries of their Centenary Exhibition, which will occupy a space one-third larger than that of 1878. It will cover the Champ de Mars, all the quay, as far as the Ministry of Foreign Affairs and the esplanade of the Invalides, on the left bank. On the right it will take in the Trocadero, and all the portion of the Champs Elysées comprised between the Seine, the Place de la Concorde, the Grande Avenue, and the Avenue d'Antin. The superficial area of the covered portion will be slightly over 3,000,000 square feet, the palaces of art and science each occupying about 360,000 square feet, and the remaining space being about equally distributed between the machinery hall and a number of intermediate constructions. According to a rough estimate, the cost is put at £2,000,000, but some French journals consider that the amount will more likely be double that sum. The Government does not propose to bring the financial provision for the scheme before the present Parliament, as it is so near to expiration. It will form the subject of deliberation after the election of the new Chamber, but it is already understood that the city of Paris will contribute a sum of about £240,000.

MEETINGS FOR THE ENSUING WEEK.

Monday, June 8... Geographical, University of London, Burlington-gardens, S.W., 2½ p.m. Annual Meeting.
British Architects, 9, Conduit-street, W., 8 p.m.

Tuesday, June 9...Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.
Photographic, 5a, Pall-mall East, S.W., 8 p.m.
Anthropological, 3, Hanover-square, W., 8 p.m. 1. Professor A. H. Keane, "The Lapps." A family of Lapps will be exhibited, by the kind permission of the authorities of the Alexandra Palace. 2. Dr. J. G. Garson, "The Physical Characteristics of the Lapps." 3. Dr. H. Rink, "The Language of the Eskimo."
Colonial Inst., Westminster Palace Hotel, Victoria-street, S.W., 8 p.m. Mr. C. E. Howard Vincent, "The British Empire of To-day."

Wednesday, June 10...Geological, Burlington-house, W., 8 p.m. 2. Mr. J. W. Hulke, "Note on the Sternal Apparatus in *Iguanodon*." 2. Messrs. J. E. Marr and T. Roberts, "The Lower Palæozoic Rocks of the Neighbourhood of Haverfordwest." 3. Mr. W. S. Gresley, "Certain Fossiliferous Nodules and Fragments of Hæmatite (sometimes Magnetite) from the so-called Permain Breccias of Leicestershire and South Derbyshire."
Microscopical, King's College, 8 p.m., W.C.
Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

Thursday, June 11...Royal, Burlington-house, W., 4½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
Society for the Encouragement of Fine Arts, 8 p.m. Conversazione at the Galleries of the Royal Institute of Painters in Water Colours, Piccadilly, W.
Telegraph-Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. Mr. W. H. Snell, "The Calculation of Mains for the Distribution of Electricity."
Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Mr. Luis Jones, "Welsh Emigration."
Mathematical, 22, Albemarle-street, W., 8 p.m.
Athenæum Society, 13, Mandeville-place, W., 8 p.m. Mr. A. N. Butt, "Our First English Printer."

Friday, June 12...United Service Institution, Whitehall-yard, S.W., 3 p.m. Discussion on the Military Prize Essay, "Should the European Army in India be continued as at present constituted, or should it be converted in whole or in part into a Local Force?"
Astronomical, Burlington-house, W., 8 p.m.
Quekett Microscopical Club, University College, W.C., 8 p.m.
New Shakspere, University College, W.C., 8 p.m. Mr. Frank Carr, "Such harmony is in immortal Soules."

Saturday, June 13...Geologists' Association. Excursion to Erith and Crayford, under the direction of Mr. F. C. Spurrell.
Physical, Science Schools, South Kensington, S.W., 3 p.m. Professors Ayrton and Perry, "The Winding of Volt-meters."
Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Journal of the Society of Arts.

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FRIDAY, JUNE 12, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ANNUAL GENERAL MEEEING.

The Council hereby give notice that the One Hundred and Thirty-first Annual General Meeting, for the purpose of receiving the Council's Report and the Treasurer's statement of receipts, payments, and expenditure during the past year, and also for the election of officers and new members, will be held, in accordance with the Bye-laws, on Wednesday, the 24th June, at 4 p.m.

(By order of the Council)

H. Trueman Wood,
Secretary.

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by the kind permission of the Executive Council of the International Inventions Exhibition, in the Exhibition-buildings, South Kensington, on Friday, the 3rd of July next.

The cards have been issued to members, each member receiving a card for himself, which is not transferable, and a card for a lady. In addition to this, tickets will be sold to members of the Society, or to persons introduced by a member, at the following prices:—Until the 20th of June, 5s. each; from that date until the 30th of June, 7s. 6d.; on the 1st, 2nd, and 3rd of July, 10s. each.

The Council, however, reserve the right of stopping the sale of tickets or of raising the price, if it is found necessary, in order to restrict the number of visitors within reasonable limits.

Tickets will only be supplied to persons presenting members' vouchers, (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter, a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase. It will greatly facilitate the arrangements if members requiring additional tickets will apply for them at as early a date as convenient.

The issue of tickets will be strictly confined to members of the Society and their friends, and to those specially invited by the Council.

There will be no admission to the Exhibition on this evening except by special ticket, and no tickets can be purchased at the Exhibition.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, May 19, 1885; Hyde Clarke in the chair.

The paper read was—

NEW BRITAIN AND THE ADJACENT ISLANDS.

By Wilfred Powell.

In approaching so vast a subject as that selected for this paper, I find that it is one that cannot be dealt with completely in a single paper. I therefore propose this evening to give a slight sketch of the arts and manners of the people inhabiting the Duke of York group and the island of New Britain, with occasional reference to that part of New Ireland adjacent to the Duke of York group, regions which I visited in 1879.

New Britain is the name of a large island in the South Pacific Ocean, lying between the parallels of 4° and 6° 30″ south, to the east of

Cape King William, in New Guinea. On the north-east it is bounded by New Ireland and New Hanover, being divided from these two by a narrow strait known as St. George's Channel, in the centre of which is situated the Duke of York Islands, on which is the head station of the Wesleyan Missionary Society for this group. It is divided, however, from New Guinea on the west by Dampier Straits, named from the great navigator who was the first to decide that New Britain was a separate island from New Guinea. Some portions of the island of New Britain were afterwards more exactly described by D'Urville, although he visited it in very bad weather. He gives it the native name of Birara, which I found to be the name also given to a part of the island some 200 miles to the north-east of that portion which he describes—a circumstance which, I think, tends to prove that at some previous date the natives of the eastern and western ends of the island were connected, though at the present time their language, appearance, and customs are very different.

I think it may be well to begin my address by describing some of the arts and customs of the Duke of York Islanders.

The people of Duke of York Island are great travellers, going long distances in their canoes, which are different from the small coasting ones, having no outrigger, and being built much in the shape of a whale boat, sharp at both ends; the planks are all lashed together and on to the ribs, the lower part being hewn out of a single piece of wood, into which the ribs are fixed and lashed to keep them in. All the seams and crevices of any kind are filled with the kernel of a nut, grated very fine and pressed into the holes. This in time gets quite hard, so that it is easier to break the wood than wrench a joint apart. The canoes are very neatly made, and much resemble those constructed by the Solomon Islanders; indeed, I think the natives of Duke of York Island must have learnt the art of building them from those people. Some whites have told me the idea was taken from the whalers' boats, but I feel sure this is not the case, these natives being not at all inventive out of their own groove.

The natives of Duke of York group appear to be a mixture of the inhabitants of New Britain and New Ireland. I fancy, at some former date, a tribe from New Britain must have been driven off the mainland (probably from Birara) and colonised the Duke of York group, beginning at the southernmost end, as here they appear to be the original inhabitants, and still hold intercourse with Birara. Then they may have gone over to New Ireland to trade for provisions, and bought wives there; this I imagine to be the case, for the Duke of York language more closely resembles that of Birara than that of New Ireland, though the New Ireland natives seem to understand Duke of York dialect, unlike as it is to their own language. In speaking of New Ireland, I, of course, refer to that part immediately opposite Duke of York group. The women have a custom in parts of this group of covering the loins, which custom only belongs to New Ireland, seeming to point to the fact that the women must have come from thence, and continue the practice; the men go entirely naked.

A practice prevails among the people of covering their hair with lime, which turns it to a light tawny red; I never remember to have seen a bald man or woman unless they were shaved, which is sometimes the case when in mourning for a relative, the head then being blackened with charcoal and oil; or sometimes for sanitary reasons.

The young women are well-made and upright, but afterwards, as they grow older, get an unnatural stoop, from the heavy burdens they carry, which they afterwards retain, whether carrying or not. They also age very quickly, which may be partly effect of climate, but perhaps comes more from the ill-treatment they receive at the hands of the men, who look upon them as quite inferior beings, existing only for their pleasure and profit. Women work in the yam patches, to prepare them for planting; they turn up the ground with sharp sticks, burning all the grass and weeds; they then plant the tubers, which, when grown, the men condescend to get up. Women also do most of the marketing, the men, as a rule, only accepting the payment. A very disagreeable skin disease prevails amongst these natives, and indeed all over these islands; it is called "buckwar," and attacks a great number of persons; it consists in a peeling off of the skin, sometimes in one part only, sometimes all over the body. It appears to be hereditary, though in children it does not show until they are three or four years old; those who suffer from it do not seem to be inconvenienced in any way, except they are continually scratching themselves. The natives attribute it to inoculation from a poisonous plant that grows in the bush, but a Wesleyan missionary told me he had treated it with partial success by giving them sulphur to

take, and rubbing flour of sulphur on the affected parts. This would give one the idea it was a kind of scabies, but in my own mind I connect it with the total absence of salt in their food. Buckwar does not appear to be catching to white men, and though whites have said to me that they have caught it, their sores, upon examination, did not seem to be the same thing, but rather to have been brought on by the heat of the climate, and by eating too much pork. Moreover, these sores soon disappear from the white man's skin, whereas natives never lose them entirely, partial recovery only being experienced, as mentioned by the missionary.

Native money in New Britain consists of small cowrie shells strung on strips of cane, which in Duke of York Islands is called "dewarra." It is measured off in lengths, first length being from hand-to-hand across the chest, with arms extended; second length, from the centre of the breast to the hand, one arm extended; the third, from the shoulder to the tip of the fingers along the arm; fourth, from the elbow to the tip of the fingers; and the fifth, finger lengths. Fish are generally bought by their length in "dewarra," unless they are too small, whilst a large pig will cost from thirty to forty lengths of the first measure, and a small one, ten.

Dewarra is made up for convenience into coils of 100 fathoms, or first lengths; sometimes as many as 600 fathoms are coiled together; but this is not often done, as it would be too bulky to remove quickly in case of invasion or war, when the women carry it away to hide. The coils are neatly covered with wicker-work, like the seats of our cane chairs. The natives will tell you they do not know where the shells come from, but the chiefs do; it is from a place called Nukani, a considerable distance down the north-west coast. The dewarra shells are first buried in earth to bleach them, after which they are tapped with a stone on the top, which breaks a small hole; they are then strung on strips of cane, and this process I believe to be done by the chiefs alone. In New Britain, measurement of this shell money is the same as here, though they call it by another name ("taboo").

At Mioko and Utuan they use another kind of money as well, this other sort being made of a little bivalve shell, through which they bore a hole and string it on native-made twine. The shell is chipped all round till it is about a quarter of an inch in diameter, and then smoothed down with sand and pumice stone. This is of no use in Duke of York Island, but is eagerly asked for in Birara. (This is another connecting link between the south of Duke of York and that district of New Britain.)

The arms the natives carry are nearly all imported from New Britain or New Ireland. Before the white man's iron trade tomahawks became so plentiful, they used to have the stone tomahawk. This they fix on to a long handle about four feet long, with carved ornaments at the end, whilst below the blade, on the handle, they cut notches to show how many men they have each killed.

Polygamy prevails here, and a man that has much dewarra can have as many wives as he pleases. The most I ever saw one man with was eight, I think, and great difficulty he seemed to have in managing them. The only way he could do so was by the help of a big stick, which, judging by the screams we heard, was freely used.

The practice of cannibalism has existed in these islands for no one knows how long, though many of the natives now know that it is abhorrent to white men, so are ashamed to speak to them about it. They prefer taking their victims alive in order to torture them. One poor fellow had been so taken from a small inland village in the Duke of York Islands that had been attacked; he managed to escape, but was caught again; they then cut off his feet, burning the stumps of his legs, to prevent his bleeding to death, and carried him to the place where they wished to eat him; mercifully, the poor fellow died before they tortured him any further.

The law of succession amongst the chiefs in this island is that, upon the death of one of them, the eldest nephew on the sister's side always succeeds his uncle, as they remark, with some sense, "that a man may always know who his mother is, but not always his father." Should the eldest sister not have any children, the eldest son of the second sister succeeds, and so on. If there be no descendant at all, the people of the district elect a new chief, choosing generally a wealthy one, as money constitutes the sinews of war, and they wish to have the one who can pay them best for fighting.

The administration of law is centered in a mysterious person called the Duk-duk, who is judge, policeman, and hangman, all in one, settling disputes and punishing offenders. He is, in reality, appointed by the chief, his dress consisting of leaves which cover the body to below the waist, whilst a

large helmet comes completely over the face and rests on the shoulders, in shape like an extinguisher. This is made of net-work, so that he can breathe and see without being seen; it is painted to represent a hideous face. This strange personage travels through the bush, stopping at each village, and if a man has received injury at the hands of anyone, he pays the Duk-duk so much dewarra to settle the question for him. The Duk duk goes off to the aggressor's house, and demands restitution, which if the accused does not make at once, the Duk-duk either sets fire to his house, or in some extreme cases spears the offender.

Women and children are never allowed to look at the Duk-duk, or they will die; this superstition is so strong that they will run away and hide themselves when they hear him coming, which is announced to them by a peculiar shrieking noise he makes as he travels along.

When the young men are old enough, they are allowed to know the secret if they can pay 100 fathoms of dewarra; if not, they must always keep out of his way. The Duk-duk goes his rounds at stated periods, after which there is a big feast and a dance, to which the initiated are admitted. The performers are dressed up in fern leaves and flowers for the occasion.

The chief has sometimes more than one Duk-duk if he can afford it. No man must lift a hand against him, and if he does not submit to all the Duk-duk does, his life is not worth a day's purchase, for the chief of that Duk-duk's district will find means of putting the offender quietly out of the way.

The secrets of the Duk-duk must not be spoken of outside the "taboo-ground" where he is supposed to live; only the initiated are allowed on that ground, under a penalty of a heavy fine, or if this be not paid, death. A sad case occured at Ruku-kuro, where a young man was driven through stress of weather in his canoe on to the "taboo-ground." It happened the Duk-duk was just holding a feast; the poor young man was seized, carried to the Duk-duk, who tomakawked him on the spot, and his body was served as part of the feast. Of course none but the initiated knew what had become of the poor young fellow.

The Duk-duk is both a curse and a blessing to his people, as he certainly keeps order, and makes the natives afraid to commit any outrageous act, whilst, on the other hand, he encourages terrorism and cannibalism. There are secret signs between the initiated, by which they know each other from outsiders. This system is widely distributed in the north peninsula of New Britain in nearly every district; also in New Ireland, from the west coast south of the Rossel Mountains to Cape St. George; and how far it spreads on the other side I cannot say. The system may, I fancy, have originated in Duke of York Island, though there are good arguments for referring it to Birara. The chief, Tor-Paulo, says it began in the Duke of York Islands; but then he lives in that group, and I find the natives always inclined to boast about the places they live in, so his statement must be taken *cum grano salis*. The evidence in favour of Birara being the original starting place of this system is supported by a legend told me by a very intelligent young native of one of the Duke of York Islands, which strengthens my belief in his story. He says:—

"A great many seasons ago (monsoons) there was a young man quarrelled with his father and whole family, and started off by himself into the bush, where, having nothing to live upon, he became very hungry, and at last he hit upon a plan to get flesh to eat. He made a large head-dress out of cane, and painted it with the juice of the betel-nut, and made eyes like the moroop's (cassowary's). He then dressed himself up in leaves, so that his hands were hidden, and yet could be used when required; he also provided himself with a club. In this dress he wandered in the bush, and, making a noise in order to frighten people, in this way surprised many yonng boys and girls, and, killing them, would carry their bodies away and eat them. At last, it got so bad, and everyone being afraid of him, his father, who was a great fighting chief, determined to go out and fight the strange monster. This he did, and eventually overcame the Duk-duk in a struggle, by which the son was thrown on the ground; he then called out that he was the chief's son, and that if he would spare him he would show him how he might become very powerful, and make much dewarra; this the chief did, and the monster that had frightened and killed so many became a subject of the chief that had conquered him; but he always lived by himself, in a house that was tabooed, and everyone was afraid to go near the place; but if anybody injured the chief, or disobeyed him at all, the Duk-duk would visit them with vengeance, and make them sorry they had anything to do with it. The real secret of this was, that, not knowing what it really was, they attributed superhuman power to it, and were therefore afraid, which, of course, gave the Duk-duk a great advantage in the event of having to fight. The women and children were ordered to keep out of its way, as it would probably kill them if it met them in the bush, and you may be sure they did not require to be told twice. As time went on, it was found

necessary to admit others into the secret, and they were admitted under an oath of secrecy, and thus it spread from one place to another."

I think the young man fully believed the truth of this story, and allowing for the time that has occured since the custom was started, it is really very likely that something of the kind did actually take place, but whether in Birara or in the Duke of York Islands, it is impossible to state. It reminds one of the "Mumbo Jumbo" superstition of Africa. Can it be possible these native tribes have kept a remnant of a tradition brought from their original birth-place?

There is also a curious custom of the Duke of York natives of propitiating the sea-god, as it appears, though they do not acknowledge any power of the water, and even make out that the wind is subservient to wind makers and doctors; therefore, I reluctantly attribute this curious and almost beautiful custom to mere swindling on the part of the chief who inaugurates it.

One chief in each district (always the same man) has a canoe built and decorated with carved wood, ferns, flowers, and scented herbs. It is then placed in a house by itself, which is "tabooed," and no one may enter without paying so much dewarra, which is placed in the canoe.

The chief, who is also a doctor, gives out that everyone must pay as much dewarra as possible into the canoe, that there may be plenty of fish caught this season, and that he (the chief) may make them easy to be caught. The dewarra is supposed then to be launched in the canoe to pay the fishes for those they lose; but the canoe is carefully covered first, and in reality not one shell of dewarra leaves the shore in that canoe, which floats away and is lost sight of. Should a bad season follow, the chief, of course, says there was not enough dewarra in the canoe. No one native I have ever spoken to believes it brings more fish, but it brings a feast and a dance, and they will do almost anything to obtain those; and the custom, though still kept up, is not believed in now. I do not think any special time of year is adhered to for this ceremony.

They have many kinds of dances in New Britain, any excuse being sufficient for a "Malargen." The usual form of the dance is in two lines, and the dancers are dressed up in variegated leaves from the *Dracæna* and other plants, and have ferns and flowers in their hands and on their heads.

There are various kinds of dances too numerous to describe, but they consist mostly of these two lines of dancers, who face each other, moving their arms and legs in correct time to the music, then turning either right or left, come round each other different ways. Were I to attempt a longer description I should get hopelessly confused; but there is one dance, however, I must try and describe, that is the "Toberran," arranged by the same chief that manages the fish canoe. It occurs about once in two seasons of the full moon, and is a wonderfully impressive sight, the men and women that take part in it being all picked dancers. About 9 o'clock p.m. we were all seated round in a large semi-circle, the other side being formed by heaps of firewood ready for lighting. We saw, as yet, no performers, but presently the "tom-toms" began to play very slowly, and the women, who were seated in front as an orchestra, began to sing a weird kind of song, sounding most like a combined wailing of cats and dogs, which gradually got faster and faster. Presently, one of the fires blazing up, we saw by its light some creatures creeping out of the bush in all directions, looking, indeed, like the devils which "toberran" means. Some wore hideous masks, made of a skull cut in a half and filled up to represent a face; these were held between the teeth by a stick which is fastened across at the back of the mouth of the skull, their heads were covered with long black wigs of cocoa-nut fibre, and their bodies with dead leaves. Some had no masks, but their faces were painted an unearthly green colour, and they had a kind of wings fastened to their shoulders, which, on closer inspection, proved to be actually fastened through the loose skin of the neck. Now these unearthly figures advanced, keeping beautiful step and time, no matter what position their bodies were in. The tom-toms suddenly stopped, and all the toberrans rushed to the centre of the open space with a fearful yell, the music then struck up again, and a dance began that defies all description, heads, arms, legs, and tails being hopelessly mixed, and yet in perfect unison, for if there was an arm one side, there was a leg to match on the other. The shrieks and yells got louder, the singing became shouting, and as the dance went on fires were lighted and blazed up, throwing their lurid light on one of the most hideous scenes I have ever witnessed. Demon faces, and toothless skulls showing here and there, arms smeared with blood waving wildly, legs apparently in the last stages of mortification; the scene

being lighted by a moon that sent a fitful light through the over-hanging trees, whilst the huge fires cast strange shadows, which suggested things more horrible even than the hideous reality.

These tom-toms, or drums, are hollow cylinders of wood burnt out, in shape somewhat like two cones joined at the apex, covered at one end with iguana skin tightly stretched over it, and are held under the arm or across the knees, and beaten with the hand. There are larger drums also used, called "garamoot," which are made of the trunk of a tree hollowed out by burning, and having a small slit at the upper side. The hollow, I believe, is burnt out by small red-hot stones dropped into the inside through the slit at the side. This cylinder is struck with the end of a long stick just below the slit, and makes a deep note that can be heard an immense distance in calm weather. It is heavy, and is, therefore, seldom moved from the dancing-ground, which is generally an open space in front of a chief's house, kept swept and clean by women who are specially appointed to look after it. The garamoot is also used for alarms in case of war, when it is struck so as to give a sharp, quick sound, and also for calling people together. There is yet another kind of drum, composed of three pieces of soft wood cut with a slight cavity on the under side. These are laid across the knees, and beaten with two short sticks with heads to them, like our small drum-sticks. The other musical instruments of these natives are, a fife, made from a small piece of bamboo, on which they can play three or four notes; pan-pipes, also made of bamboo, with six or seven pipes; a jewsharp, very cleverly made of a piece of bamboo, cut in a shape resembling the fern leaf we call hart's tongue, with a vibrator down the centre, which is played resting against the mouth in the same manner as our jewsharps, except that it is played with the thumb of the left hand, having a piece of string passed tightly over it from the thick end of the instrument, and is struck against the vibrator. There is also a small instrument which looks like the primitive form of a banjo. It consists of a large piece of bamboo cut through at the joint horizontally, and again about three or four inches above the joint, with another small piece of flat bamboo fastened across the mouth, and projecting beyond the edge of the circular piece about three inches, very much in the shape of a small banjo. It has but two strings, and those are made from a piece of the outer bark of a cane that grows in these islands; these are stretched tightly along the projecting piece of bamboo, and fastened below to the larger piece with a wooden peg. It is played with a small stick, which is struck against the strings sharply, making two humming notes. These musical instruments appear to be common to all these islands, and are to be seen at any of the villages, and in almost every house, with the exception of the large drums, which belong especially to chiefs.

The ornaments of the Duke of York natives are few, and considerably less used than in either New Britain or New Ireland; they consist chiefly of dewarra shells, strung together to form necklets, or placed round the head. The ear lobes are cut and distended by the use of rolled leaves of a springy description, generally of pandanas, which, constantly pressing against the sides of the opening, enlarge it, till in some cases the lobe hangs nearly down to the shoulders. The nose is also pierced on each side of the nostril, and a small sharp-pointed piece of wood inserted in each hole; on the wood is threaded a few beads (when they have them), but more commonly there is nothing but the wood, which I was informed acts as a sight for throwing the spear, though I can scarcely think it would help a European to do anything but squint. Variegated leaves are tucked under the armlet, which is made of plaited twine, and dyed with different coloured juices; these armlets are worn so tight that they squeeze the arm out of shape, and in most cases cannot be got off except by cutting or oiling and pressing the arm. The natives of the northern end of the Duke of York's group wear no clothes of any kind; indeed the men over the whole group wear nothing, but the women of Mioko Utuan and the southern peninsula wear a small cover before and behind, made of grass, and dyed a bright red.

They fish with the rod, the hook being made of tortoiseshell, but more often prefer fishing on the reefs with a small narrow net which they spread out with stakes, and drive the fish into it, so that they become meshed. They have also a net stretched on poles, something like a shrimping net, with which they catch the large shoals of small fish that at certain seasons visit these shores, and that are delicious eating.

It is a curious and noticeable fact that there are no cassowaries to be found on Duke of York Island. Neither are the white cockatoo ever seen there, although in New Britain there

are a great many of the former and thousands of the latter. The only cockatoos in the Duke of York Islands are those that have been brought over from New Britain, and they always return to that island should they escape. I cannot find any reason for this, as there appears to be much the same food for these birds on one island as on the other; the cassowaries may have all been killed off, as Duke of York is more thickly-populated than New Britain. But then one would expect to find them in New Ireland, but there are none there. Duke of York Islands are but fourteen or fifteen miles away from New Britain at the furthest distance, and New Ireland is only thirty miles or so—a space easily traversed by the cockatoo. I can see no plausible reason for their non-existence.

The fruit of Duke of York consists of the banana, cocoanut, tan, mummy apple, and a description of wild mango. Yams and taro also grown on the island, but sweet potatoes are the chief product, and serve as one of the main articles of trade between this and the other islands.

The bananas also are in some parts of the island very fine, but the yams and taro are not to be compared with those of New Britain, or the yams of New Ireland, which are noted for their large size. The taro of New Britain is also considered the finest in the South Seas. Taro is a large bulbous tuber, with leaves much of the shape of the *Caladium*. I have never seen the flower. There are two different kinds, one of which grows in swampy ground, and the other on the hill-sides; the latter is the largest and best, the swamp taro being waxy to eat. Taro is planted in rows, about one pace apart, and is kept clear of weeds by the women; the hill taro grows to the size of fifteen inches long, by one foot circumference. When cooked in a small quantity of water, the starch that exudes from it makes the water into a thick paste, therefore it requires more water added continually, and when cooked, is soft and mealy, and is one of the very best vegetables I have ever eaten. The native way of cooking it is even better than boiling; the outside rough brown coating is scraped off with a sharp shell, and after cutting the taro in halves lengthways, it is wrapped up in banana leaves, and placed in a fire where it is not too hot; when cooked, it is much like good new bread, and is excessively nutritious. After taking the tara out of the ground, the tuber is cut off, leaving about an inch still adhering to the stalks and leaves; this is again placed in the ground, and in about three months has another large tuber ready for cutting. The leaves are terribly astringent, and, if eaten raw, will take the skin off the mouth, and render it very sore for some days, but the young leaves, cooked, are very delicious.

There is also a fruit called the "tan," which I don't suppose many Europeans know much about. It grows on very high trees, whose wood, by the way, is beautifully grained and very hard, though nice to work. The fruit is shaped much like an apple, and also grows in bunches as some apples do, but if you take one in your hand and press it, when ripe, the skin will come clean off, and the inside is then found to be beautifully clear jelly-like substance, which, when placed in the mouth, melts into water. This jelly surrounds a brown stone, of which the natives make a sort of cake, after it has been soaked for some days. The "papau," or mummy apple, has also some curious facts connected with it that are useful to know. The very young apples, when boiled, make a most delicate substitute for vegetable marrow; the stalks and leaves, if boiled with clothes, will render them beautifully clean and white; they come out of the boiler a bright gamboge yellow, but when hung up to dry in the air, they turn perfectly white again; a small piece of the leaf or stalk, boiled with an old fowl or tough piece of meat, makes it quite tender.

Here it may be well to give some account of woman's social position. They have a saying in New Britain, "Never trust any secret to a woman, for their tongues are hung with a double joint." When a man intends to take a wife, he tells his father who it is; or if he has no father, he tells his mother or the chief of the district. They then send him off into the bush, where he stays for some days, till his father calls him back; meanwhile, the father and mother go to the girl's relations, and, after making them presents, say they will pay so much dewarra for the girl. They haggle a good deal over the price; the girl's relations generally getting it raised; when settled, the father and mother go home. On the day fixed, all the young woman's relations go to the house of the man's father and mother, who, if rich people, have invited many friends to meet them; the former give presents to their hosts; there is a feast and a dance; also a young women's dance, in which the bride takes a leading part. The feasting over, the young woman remains with the young man's parents, and he is called back from the

bush. That is, some one is sent to find him, often a difficult matter, as, the spirits of the departed relations being said to exercise a bad influence at this time, the young men often go long distances to escape them. It sometimes happens they never return, having been killed by an enemy's tribe. Should a chief wish to marry into any particular family, he buys the child as soon as there is a prospect of one being born. If it turns out to be a boy, the money is returned; if a girl, it is kept by her family, but the girl becomes the property and ultimately the wife of the chief, though she remains with her parents until she is ten years old, the marriageable age. After marriage, the woman becomes the complete property of the man, who has even power over her life; for instance, a chief living on the shores of Blanche Bay had purchased a young wife who would not work, but only cried and wanted to go back to her friends. Her husband became angry, and telling her that as she was of no use as a wife, he would make her useful in another way, he killed her and cooked her body for a feast. There was also another case, where a man belonging to a bush-tribe was taken prisoner, with his wife, by a sub-chief and a few followers, in the bush. The man was killed, but the woman was taken to be one of the sub-chief's wives; the marriage feast was the body of her late husband.

The laws against intermarriage are very strict, and there are in every tribe two distinct parties between whom only is marriage allowed, the men generally buying women from foreign tribes. The chief's permission must be asked before a marriage can be contracted. If a young man wants to purchase a wife, and is unable to do so, he goes to his chief and asks him to buy one for him. If the chief knows the young man is likely to be able to pay him back in some way, he will both purchase the wife and make a feast on the occasion, but the chiefs are careful to see there is a chance of their being repaid in some way. The women carry their babies in network bags, the band of which passes round the forehead, whilst the bag rests on the shoulders; they will also at the same time carry two or three cocoa-nut mat bags full of merchandise on their backs; this gives them the stooping gait already mentioned. Women also suffer from buckwar, which appears to turn their skin a lighter colour than when it is healthy.

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the fingers, the other string being finished off to a taper point. The two strings are joined by a flat piece of bark of the cocoa-nut tree, serving as the receptacle for the stone. In throwing, two ends of the string are held in the right hand, the button being between the second and third fingers; the stone, resting on the piece of bark, is swung rapidly round and round the head, the right arm bent, and when sufficient impetus has been given, the pointed end of the string is let go, and the stone flies, the string at the same time cracking like a whip. I have seen a man knock a bird off a tree at about 100 yards distance. They seldom pitch their stone further than three or four yards from the object aimed at.

There are several kinds of spears too. Those most commonly used are made from the hard outside bark of the cocoa-nut palm; they have the sharp point burnt in the fire a little, to harden it, the other parts being left quite plain and rough. Others are made of tan wood, which is very tough; others from a bastard ebony that grows in these islands; these last are generally quite plain. The spears they use for "close quarters" have often a shin or arm bone stuck on to the butt end of them. They attach a superstitious value to these bones, which are those of an enemy killed in fighting, supposing them to give the throwing power of the man to whom the bones belong. Spears used on festive occasions are much decorated with a conical-shaped arrangement of feathers, blue, green, red, and white being the favourite colours, and the feathers being taken from the gay plumaged parrots that abound in these islands. Clubs used in the dances are also decorated in the same way, and in these dances too they use "Malargens." These are thin pieces of wood carved with figures of men or animals, and so light and thin that they bend and shake with each movement of the dancer, who often carries one in each hand. The reason these natives use the skulls of departed friends in dancing, is that they believe the skull to be the place to which the spirit of the departed returns after death.

The surgical instruments used by these people are simple in the extreme, being a piece of obsidian, a shark's tooth (and if they can get it) a piece of glass bottle. The doctors bleed for every ailment, cutting the part affected. If a man has only a head-ache they bleed him—tying a tight band round the head, and cut deep gashes in the skin, until the blood flows freely. When sufficient blood has been removed, they stop the bleeding with burnt lime. Men are often seen covered, on face, chest, arms, legs, and stomach, with the scars made by the bleeding instrument. These same doctors also pretend to all sorts of powers —to be wind or rain makers and magicians, and to be able to cure everything, or make anyone ill, however distant he may be; also to control the wind and rain. There is much trickery mixed up with something that is real in their practice, though the natives have much faith in them.

With respect to the religion of these natives, it is difficult to speak with assurance, as there appears to be, at first sight, no positive law, order, or even similitude of ideas in any two places. The real fact is, they have no knowledge of any God—that is to say, one to be worshipped. They have, however, a belief in a creative being, that originally formed the land on which they live, but he is always spoken of as a being that was at a very remote period, and not as one that is now in existence. I have heard some declare that it was a huge pig that rooted up the earth, and so formed the mountains and valleys. This has been stated as proving that the history of the creation, as accepted by the Christian religion, is thus held in a shadowy form by these natives; but I fear that there is too much sentiment allowed to find its way into this theory, and that it is more probably to be accounted for by the necessity for a being with reason having to supply the cause of these natural phenomena.

These natives are very superstitious regarding the spirits of their departed friends or enemies, whom they consider to have either a good or bad influence as the case may be. In conversation one day with an old man about the spirits of the deceased, he explained to me that the stars were lamps hung by the departed spirits, to light the way for those that should come after. Although I questioned him closely on the subject, he had no idea as to the place that they reached at last, he only knew that the spirits went across the water to the moon at its rising, and getting into her were carried to the region of stars, and that they returned to visit the earth by the same means. I tried to puzzle him by asking how it was that the moon was sometimes large and sometimes small; he replied that when it was small there were not so many spirits requiring to go, as it was always at a full moon that the most people die.

These natives are extremely fond of dog's flesh, but it is only on rare occasions that one is cooked, and that when a chief dies, and a

feast is made by his successor. The flesh of young alligators is also considered a great delicacy. The cassowary, wallaby, and magapode are eaten. Fowls' eggs are very numerous, as also, in some parts, are those of the magapode. Cassowaries' eggs are generally blown before eaten. Turtles' eggs are consumed in large quantities, both raw and cooked. There is a large description of spider that is considered a very delicate article of food.

Their method of cooking is to make a hole in the ground, and light a fire in it; into this is dropped a number of hard stones that become red hot. Should it be a pig they intend cooking, some of these stones are taken out, and placed inside the carcase, subsequent to its having been singed over a grass fire and cleaned; it is then wrapped in banana leaves, placed in the hole, covered with the remainder of the stones, and again covered with banana leaves, and finally heaped up with earth; the pig will become thoroughly cooked in about two hours.

In fishing, these natives use beautifully made fish traps, as well as the rod and net. These traps are moored with a rope made of lengths of cane twisted together, and attached to a stone. This kind of fishing is often practised in great depths of water (100 fathoms). The fish-trap is made of plaited cane, neatly worked in pattern something like the seat of a cane chair, and is oblong in form, open at both ends, with a number of slight canes converging from the opening to the centre, where a space is left for the fish-trap, these canes being pointed, the fish on trying to return are met by the points, and so cannot get out.

Another mode of catching fish is with a number of prickly palm branches, which are all tied together at one end, and worked round with fibre, so as to form a cone with the hooked thorns pointing inwards towards the apex, where a piece of bait is fixed. With this trap the native dives, and places it on the edge of a reef; a bit of light wood is fastened to the trap with a string, which floats on the surface of the water, and shows by its motion when the fish is entangled in the thorns of the trap.

Hooks for lines are made of tortoise-shell, and the bait is formed of pearl shell in the shape of a fish, having a tortoise-shell hook on the tail. They also use a spear with five points, four on the outside and one in the middle. There is a description of creeper which, when bruised and thrown into the water, the fish eat, and appear then to become intoxicated, floating on the surface quite helplessly, and falling an easy prey to the fishermen.

The houses of these natives are not, as a general rule, of a very high order, being often only small huts made of bamboo, thatched with either grass or sugar-cane leaves. For each village two large houses are built, one for the men, the other for the women. No man is allowed to enter the women's house, nor any women the men's. This latter is generally used for a council house, and is lined with bunks made of bamboo, and ornamented with the spears, tomahawks, and clubs of the occupants. Each married native has, besides these common houses, a smaller one of his own. These are generally built in the form of an ellipse, the eaves of the thatch coming down to within three feet of the ground; but inside, the walls are 6 ft. high, over which the roof arches to about 18 ft. The inside is carefully blackened with the smoke of cocoanut shells, which forms a description of enamel, and does not rub off. It also, the natives assured me, preserves the rafters and timbers from rot and worm. Opposite the chief's house is generally placed the "taboo" tree, decorated with the lower jawbones of pigs, which are hung in profusion over it. It is on this tree that the unfortunate victims of cannibalism are despatched and their bodies exposed for sale.

These people bury their dead under the hut of the deceased, after which the relatives go away for some months. This is done for sanitary reasons evidently, as the bodies are buried so near the surface that the smell would, in all probability, make anyone sleeping in the hut ill. But their reason for so doing is because the spirit of the departed stays in his late residence for some time after his death, and eventually finding no one to torment, goes away for good. The surviving relations then return, and live in the hut as before. No doubt the coral acts much as quicklime, and disposes of the decomposing portions of the body in a short time.

In concluding this short description of the manners and lives of these most interesting people, I would just mention that the climate of these islands is such as to forbid all feeling of envy at their annexation by Germany, as, indeed, it is an impossibility for white men (Europeans) to make any continued residence on them, for even two or three years, without suffering much injury to their health, in con-

sequence of the malarious fevers that abound in them. I should have liked, had there been time, to have made some further remarks—on methods of counting, language, trade, and culture, but I fear that I must have quite reached the limit allowed, and, therefore, here bring my paper to a close, with the expression of a hope that it will be found to have been not without some interest to the meeting.

DISCUSSION.

Mr. Frederick Young said that in listening to the paper which had been read, one could not fail to be impressed with the very graphic account which Mr. Powell had given of a very remarkable and, at the same time, a most interesting people; and it struck him that among those people they saw some of those types of the primeval man, which showed the intelligence of the human race combined with certain of the barbarous attributes which horrified them, such as cannibalism, which prevailed amongst them, and many other customs which were quite contrary to our notions of civilisation. At the same time he could not help being forcibly struck with the fact which it was very necessary always to bear in mind, namely, that that particular feature of barbarism which they looked upon with such horror—cannibalism—might be exterminated by contact with civilisation. They saw notable instances of this in the case of New Zealand and Fiji. He happened to be well acquainted with the commencement of colonisation in New Zealand. When first New Zealand was colonised in 1838 or 1839, cannibalism was prevalent to a very large extent, and now the practice was entirely extirpated. Subsequently, the islands of Fiji came under notice, and the same state of things was found there. With regard to the concluding remarks of Mr. Powell as to the annexation of New Britain by Germany, he (Mr. Young) said he was glad to have an opportunity of making a few remarks on the subject, because he was one of those who felt that Great Britain had no reason whatever to be jealous of other European nations taking what might be called the unoccupied parts of the world's surface, if they chose to do so. Englishmen were not to imagine that they were to be the possessors of the whole world, and that no other European nation was to have part or parcel in it. The only reservation he would make was, that there were certain points connnected with our vast Colonial Empire which were spoken of as strategic points for defence, and which it was necessary for us to safeguard, and endeavour to claim and preserve, for our own Empire. In the case of these islands to which reference had been made, however, the great Australasian portion of our Empire were more interested than we were at home. It was, at all events, a very great thing to think that any European power might come among those savages, and infuse somewhat of European civilisation into them, which might alter the whole character of the people; might change them from a state of savagery to one of civilisation; might improve them—teach them to be clothed instead of unclothed, make them traders, and beneficial to the rest of the world. In fact, there was no end to the improvement which might take place in future ages, from their contact with European nations.

Dr. Mann said there was one point to which he wished to draw attention, and which struck him as being noteworthy. The general picture placed before them of the people of these islands was not a very attractive one, and, personally, he should feel very little inclination to go amongst them. He thought that the cannibalism which existed among them indicated a very low stage of barbarism, though that no doubt did and would disappear before the advance of civilisation. The point to which he wished to draw attention was that people so barbarous as to be actually at the present time practising cannibalism, should have such a singularly beautiful and poetical idea present in their minds as the notion of the use of the moon, when in apparent contact with the earth's horizon at rising, as a means for the transport of departed spirits to the stars. The paper which had been read was one which contained much valuable information, but was not one which admitted of much discussion. He would like, however, to ask Mr. Powell whether the population of these islands was large.

Mr. Dicken said that the account which had been given of the manners and customs of the people of these islands had been a most accurate and interesting one. Some years ago, he was fortunate enough to obtain a collection of weapons and other things from New Guinea, which he had shown to many people, and they were invariably struck with the fact that such barbarians could possibly have worked such very fine work in tortoise shell and other things. Their canoes and paddles also were beautifully made. He hoped, now that the islands had been taken over by a European power, there would be an end to cannibalism and other practices which were so detestable to Europeans.

The Chairman said that one point which had been dealt with by Mr. Powell in his paper, came especially within the objects of the Society of Arts, namely, cowries used as money in many parts of the world, and which had been in use from the most ancient times, even before history down to the present day. He quite agreed with Mr. Powell's account as to the Duk-duk having a close resemblance to the Mumbo-jumbo. In the latter case the public officer was equally disguised, and there was no doubt that the legend was only an invention to account for the institution of the practice.

There was no reason to suppose that the institution had its origin in New Ireland, because it was no doubt connected with other ancient institutions which were represented as had been intimated in the old continent. It was generally assumed that when they came across savage populations they must be credited with the ingenuity or the value of an institution which they possessed, but it would be just as reasonable to credit them with having made the watches or other articles which might have been taken from a wreck or obtained by robbery. It was very seldom indeed that the institutions of a population in a low state really belonged to it, and they were no doubt the inventions of a higher class population which had formerly occupied the country. The Chairman then proceeded to point out that there were many words in use in the whole of these groups of islands which could be traced to an African source, and which were so absolutely identical that the commonest observer would not dare to deny them. Mr. Powell had not referred to the historical part of the question. To a great extent these islands were of interest to Englishmen, because they were chiefly discovered by Englishmen, the famous Dampier, Cook, and Hunter. Captain Cook thought that these islands were of more value than they had proved to be, and it was evident that in naming them New Britain, New Caledonia, and New Ireland, he hoped that he was laying the foundations of what were ultimately to be settlements of this country. As to the annexation of these islands by Germany, the Chairman thought it made very little difference as to who had possession of them, because they must all agree in that sentiment which had been expressed by Mr. Young that this country had no desire of monopoly in these matters, and there was not one of these possessions to which foreign nationalities were not quite as welcome to send ships to trade and to settle as this country was. The Chairman then proceeded to give a general review of the proceedings of the Section, and reminded the audience that the meetings had been held for the express purpose of calling attention to the important colonial interests which so materially affected the welfare of the Empire. In conclusion, he proposed a hearty vote of thanks to Mr. Powell.

In reply to Dr. MANN,

Mr. WILFRED POWELL said that, with regard to the population, the Duke of York Island was very thickly populated. New Britain was becoming depopulated by the internecine wars and cannibalism. He had seen as many as twenty bodies at one time, cut up in the same way as a bullock or sheep would be cut, ready for sale to the highest bidder. He thought that Dr. Mann was slightly in error with regard to the natives being low savages. The Fijians, although they were bred cannibals, were, at the same time, comparatively, a very high class of natives indeed in regard to their manufactures and culture, and the same might be said with regard to New Britain. There were many races at present in the northern part of Australia who, though they were not cannibals, were perhaps the lowest race of men on the face of the earth.

Dr. MANN said his remark was that they were in a low state of savagery; he referred to their actual condition, rather than to their organisation or capability.

Mr. POWELL then proceeded to deal with the similarity of the language to that of other countries, and instanced words in the Malay, Roman, Syrian, and Arabic tongues, and modes of counting, which he thought positively proved his proposition.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

H.R.H. the Duke of Edinburgh, K.G., has consented to act as as Chairman of the Musical Jury. A list of the Jury will be printed in the next number of the *Journal*.

A performance of the Strauss Orchestra was held in the Royal Albert Hall on Tuesday afternoon, 9th inst.

The number of visitors to the Exhibition for the week ending Tuesday, 9th inst., was 139,122. Total since the opening, 672,139.

GREENWICH OBSERVATORY.

The annual visitation of the Royal Observatory was held on Saturday, 6th inst., when the Report of the Astronomer Royal was presented to the Board of Visitors. The report refers to the period of twelve months, from May 21, 1884, to May 20, 1885, and exhibits the state of the Observatory on the last-named day.

The following are a few of the points referred to by Mr. Christie:—

In order to determine absolute personal equations in the observation of slow-moving as well as of quick-moving stars of various magnitudes (whether the motion be from right to left or the reverse) and of limbs of the sun, moon, or planets, I have arranged, in concert with Mr. Simms, a personal equation instrument to be used with the transit-circle. In this instrument, which is on the point of completion, a vertical plate with a circular aperture, 6 inches in diameter, to represent the sun or moon, and several small pinholes, to represent stars of different magnitudes, is placed in the focus of an object-glass of about 7 inches aperture and of about 50 feet focal length (which is attached to the dew-cap of the transit-circle, when horizontal and point-

ing north), and is carried smoothly by clockwork from east to west, or west to east, at a rate which may be varied at will from that of a very close circumpolar star to three or four times that of an equatoreal star, by an ingenious but simple mechanical contrivance devised by Mr. Simms. The apertures in the vertical plate are illuminated by direct sun-light or moon-light reflected by a plane mirror towards the object-glass, and the times of transit of the artificial sun, moon, or stars, which are to be observed over the wires of the transit-circle, are also registered automatically on the chronograph by means of insulated platinum studs, corresponding to the artificial objects which make contact with other studs corresponding to the wires in the field of view of the transit-circle.

On January 1st, the public clock at the Observatory entrance and the other mean solar clocks were put forward 12 hours so as to show Greenwich civil time, starting at midnight and reckoning from 0^h to 24^h, which would correspond with the universal time recommended by the Washington Conference. The change from astronomical to civil reckoning has also been made in all the internal work of the Observatory, and has been carried out without any difficulty. Greenwich civil time is found to be more convenient on the whole for the purposes of this Observatory, but its introduction into the printed astronomical observations has been deferred, to allow time for a general agreement amongst astronomers to be arrived at. It is proposed, however, to adopt the civil day without further delay in the printed magnetical results, thus reverting to the practice previous to 1848, and make the time-reckoning harmonise with that used in the meteorological results, the reckoning from 0^h to 24^h being, for the future, adopted in both cases.

In the twelve months ending May 20, 1885, photographs of the sun have been taken on 173 days, and of these, 431 have been selected for preservation. The mean spotted area of the sun was slightly less in 1884 than in 1883, and slightly greater than in 1882, whilst the faculæ, in 1884, showed a slight increase as compared with 1883, and a slight falling off as compared with 1882. It would seem that the maximum, both of sun-spots and faculæ, occurred about the end of 1883, or beginning of 1884.

The mean temperature of the year 1884 was 50°·7, being 1°·4 higher than the average of the last 43 years. The highest air temperature (in the shade) was 94°·1 on Aug. 11, and the lowest 24°·5 on Nov. 25. The mean monthly temperature was above the average, excepting in the months of April, June, October and November.

The mean daily motion of the air, in 1884, was 286 miles, being 3 miles greater than the average of the last 17 years. The greatest daily motion was 891 miles on Jan. 23, and the least 78 miles on Feb. 8. The only recorded pressure exceeding 20 lbs. on the square foot, in 1884, was 22·7 lbs. on Jan. 23, after which the connecting chain of the pressure plate broke, as mentioned in the last report.

The number of hours of bright sunshine recorded by Campbell's sunshine instrument, during 1884, was 1,115, which is about 100 hours less than the average of the seven preceding years. The aggregate number of hours during which the sun was above the horizon was 4,465, so that the mean proportion of sunshine for the year was 0·250, constant sunshine being represented by 1.

The rainfall in 1884 was 18·0 inches, being about 7 inches below the average of the last 40 years.

The automatic drop of the Greenwich time-ball failed on 6 days through the clock-train stopping. The ball was not raised on 3 days on account of the violence of the wind.

As regards the Deal time-ball, which is now dropped by current passing through the chronopher of the Post-office telegraphs, there have been 14 cases of failure owing to interruption of the telegraphic connections, and on one day the current was too weak to release the trigger without the assistance of the attendant.

The errors of the Westminster clock have been under 1 sec. on 50 per cent. of the days of observation, between 1 sec. and 2 secs. on 29 per cent., between 2 secs. and 3 secs. on 10 per cent., between 3 secs. and 4 secs. on 7 per cent., and over 4 secs. on 4 per cent.

WINE PRODUCTION IN MADEIRA.

Consul Charlesworth, writing on the past and present condition of the wine trade of Madeira, says that the cultivation of the vine in Madeira dates back to a time immediately succeeding the discovery of the island in the 15th century, but did not for some two hundred years after exceed in export value the product of the sugar-cane. The ascendency once gained, the sugar-cane gave place to the vine, which continued its supremacy until the disease, known as the *oidium tuckeri*, made its appearance in 1852. This effectually checked the wine trade of Madeira, and in that year it is stated that not a single gallon of wine was made, and but little in the ten years succeeding. The stocks of old wine in the warehouses, representing every vintage in this century, became almost depleted, and so general was the destruction of the vine, that it was thought useless to replace with new cuttings those that had died. The total annual production of wine was never actually known, as, up to the year 1875, one-tenth of everything in kind went to the Crown, and as a result there was a regular system of concealment of the true yield practised. It is estimated, however, that from the year 1813 to the year 1825 inclusive, the average exports were 15,833 pipes annually, but from the year 1826 to 1852, the annual average export was 7,512 pipes, or a little less than one-half that of the former period. This disparity appears to be att utable to two causes. In the years of the greatest production, which were during the

wars with Napoleon, Madeira was garrisoned with British troops, and being safe, she reaped the benefit of an almost exclusive market, while the vineyards of the Peninsula were overrun with the contending armies. Prior to this period, none but the best wines had been sent abroad, and the brands of Madeira were considered the best in the world. The excessive demand, and consequent high prices that prevailed, resulted in causing wines to be sent to Europe that before were not considered fit for export. Again, until the year 1823, brandy and rum for fortifying wines were admitted to the island at a very low duty. In that year a law was passed prohibiting the importation of any kind of spirit not in bottle, and that at an almost prohibitory rate. This was intended as a measure of relief, and it stopped the importation of brandy and rum, and had the desired effect of causing the distillation of the inferior wines, of which, after the period of inflation, the island had a surplus for which there was no adequate demand. Madeira being a wine of greater density than the wines of the Continent, requires a greater length of time to bring it to maturity; and this is largely obviated by a process of artificial heating. The larger dealers have *estufas*, places for storing the wine and subjecting it to a long period of great heat by means of heated flues. Others depend on solar rays, and have elevated places inclosed with glass, in which the casks are exposed to the sun. By this means a temperature of from 120° to 130° Fahr. is obtained throughout the day. Greater heat is secured in the *estufas*, and a shorter time for the operation is required. The best wines, however, are those which are subjected to no artificial process of ripening, but are stored in a natural temperature, there to remain until time has given it both body and aroma. Consul Charlesworth says that the very ancient practice of treading out the wine with the feet is still in vogue. The grapes are placed in a large wooden or stone vat, in which the peasants, with legs bare to the knees, travel in a circle until the grapes are reduced to a pulp, which is placed in a press with a long sweep and wooden screw, and it is held in its place by binding it with cord until the operation is finished. If not too far from the shore, the must is put into casks and conveyed by boats to the merchants in Funchal; and if the vineyard is far inland, it is put into goat skins and sewed up closely with the wool inside. These are carried on a pole across the shoulders, and disposed of to the wine merchants, as whose hands it undergoes the operations of racking and fermentation. It then receives the necessary amount of spirit, and either undergoes the heating process before described, or is stored in warehouses until it has acquired the proper age for use. There are many kinds of wine made in Madeira, some of which are rarely met with outside the islands. Those of commercial value, and that are best known abroad, are the Malmsey, Bual, Sercial, Tinta, and Madeira, and each have distinct properties that are easily distinguished. Malmsey is a light-coloured wine, made from a large oval grape of a rich gold colour when ripe. By the growers it is considered an unprofitable vine, the flower being easily blighted. On account of its very rich character, it is esteemed the most valuable of all the Madeira wines, and commands a high price. Bual is a soft and delicate wine, made from a round straw-coloured grape which it is necessary to cut as soon as it is ripened, otherwise it shrivels up and yields but little juice. This wine is very rich and delicate, and is considered good either new or old. Sercial is a dry, light-coloured wine, of strong aroma and high flavour, and is not considered fit for the table until it is ten years old. When new its taste is very unpleasant, and the grape is quite uneatable. Tinta is sometimes called Madeira-Burgundy, on account of its dark colour. It receives its colour from the husks of the grape, which are allowed to remain in the wine during the process of fermentation, and which impart to it an astringent property, not unlike port. This wine is best when from one to two years old, but after that period it is said to lose its flavour. Madeira is the principal wine of the island, and is made from a variety of grapes, both dark and light-coloured, mixed together in the wine press. When new, it is of a light claret colour, but as it advances towards maturity it gives way to a bright amber. This wine is more largely produced than all the others combined, and improves with age almost indefinitely. The first four wines are made in limited quantities only, and are sold at from 25s. to 50s. per gallon, while the different brands of Madeira are sold at prices varying between 9s. and 21s. per gallon, more depending on age than on adventitious conditions.

General Notes.

Parkes Museum.—An Exhibition of Domestic Gas Appliances was opened at the Museum, 74A, Margaret-street, on Monday, 8th inst., and will remain open until Saturday, 27th. Lectures upon cookery and practical demonstrations of the uses of the various appliances will be given daily in the Museum by Miss Young. The lectures will commence each day at 3 p.m., and on Mondays, Wednesdays, and Saturdays, will be given at 7 p.m. as well.

Electric Lighting in Italy.—The installation for the electric lighting of the railway station of San Pierdarena is nearly completed. The dynamos will be driven by two turbines; the nine arc lamps are of 6,000 candle power each; the cost is estimated at £4,000. The little town of Aosta has recently been successfully illuminated. The lamps used are the incandescent ones, invented and made by Signor Czuto, of Piossasco, which gave such satisfactory results last year at the Turin Exhibition. The current is supplied by a Thury dynamo.

IMPORTATION OF ORANGES TO FRANCE.—In 1884, the total quantity of oranges imported to and sold in France amounted to 52,000,000 kilogrammes (or at an average rate of 1,000,000 kilogrammes per week), to the value of 13,000,000 of lire. At Marseilles, particularly, the importation of this fruit was very considerable, amounting to upwards of 13,000,000 kilogrammes, of which 6,477,335 kilogrammes from Spain; 4,847,470 kilogrammes from Algeria; 1,162,890 kilogrammes from Italy, and 476,389 kilogrammes from other countries.

LARGE CASTING IN ITALY.—The largest casting ever attempted in Italy was successfully accomplished at the ironworks of Signor Gregorini, of Levere, on the Lake of Isao, Lombardy. This colossal block of cast-iron, measuring 14 cubic metres (494·43 cubic feet), and weighing 107 tons (105 English tons), is intended for the anvil of a 10 ton steam-hammer now being constructed for the Royal Arsenal of Spegia. The operation occupied twenty-three hours.

PRISON LABOUR IN GERMANY.—An agitation has recently been organised in Germany against the production of artificial flowers in Prussian state prisons. The opponents of the system have urged its injustice in their representations to the Government, but the official replies bring forward the fact that the varying population of the prisons must be occupied in work which does not require a long period of instruction, if their labour is to be at all productive. The argument is likewise adduced that a large proportion of the flowers thus made are exported, and that the national industry has not really suffered such a grievance as might be assumed.

CUTTING GLASS BY ELECTRICITY. — Electricity has now been applied for cutting glass tubes, an operation of some difficulty when the diameter is large; and iron wire half a millimeter in diameter is wound round the tube at the place required to be cut, and the ends are connected by means of copper conductors of the same diameter, with the poles of a powerful battery or other generator of electricity. This iron becomes heated when the current flows, and it is only necessary to cool it suddenly with a few drops of cold water in order to produce a clear cut. Glass tubes four inches in diameter are now cut in this way.

DARWIN MEMORIAL.—On Tuesday, 9th inst., the statue of Charles Darwin, by J. E. Boehm, R.A., placed in the great hall of the Natural History Museum at South Kensington, was presented to the Trustees of the British Museum by Professor Huxley, P.R.S., as Chairman of the Darwin Memorial Committee, and received on behalf of the trustees by H.R.H. the Prince of Wales. In concluding his reply to Professor Huxley the Prince said—"It has given me much pleasure to learn that the memorial has received so much support in foreign countries that it may be regarded as cosmopolitan rather than as simply national; while the fact that persons of every condition of life have contributed to it affords remarkable evidence of the popular interest in the discussion of scientific problems. A memorial to which all nations and all classes of society have contributed cannot be more fitly lodged than in our museum, which, though national, is open to all the world, and the resources of which are at the disposal of every student of nature, whatever his condition or his country, who enters our doors."

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 15...Inventors' Institute, Lonsdale-chambers, Chancery-lane, W.C., 8 p.m. Resumed Discussion on the Patent Act, 1883.

Asiatic, 22, Albemarle-street, W., 4 p.m. Mr. H. F. W. Holt, "The Chinese Game of Chess."

TUESDAY, JUNE 16...Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m. Mr. R. Price-Williams, "The Population of London, 1801-1881."

Zoological, 11, Hanover-square, W, 8½ p.m. 1 Dr. G. Hartlaub, "A new Species of *Psittacula*." 2. Dr. Guillemard (1), "The Kamtchatkan Wild Sheep;" (2) "The Birds collected during the Voyage of the Yacht *Marchesa*." Part VI. "New Guinea and the Papuan Islands."

WEDNESDAY, JUNE 17...Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Dr. William Marcet, "Meteorological Observations made on a Trip up the Nile, February and March, 1885." 2. Dr. H. H. Hildebrandsson, "The Mean Direction of Cirrus Clouds over Europe." 3. Dr. A. Woeikoff, "The Influence of Accumulations of Snow on Climate." 4. Mr. Charles Harding, "Note on the Weather of January 1881." 5. Lieut. Alexander Leeper, "Results of Meteorological Observations made in the Solomon Group, 1882-4." 6. Mr. David Cunningham, "Graphic Hygrometrical Table."

Botanic, Inner Circle, Regent's-park, N.W., 2 p m. Summer Exhibition.

THURSDAY, JUNE 18...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Prof. E. Ray Lankester, "*Golfingia Mac Intoshii*—A new Sipunculid from the Coast of Scotland." 2. Mr. D. H. Scott, "The Occurrence of Articulated lacticiferous vessels in *Hevea*."

Chemical, Burlington-house, W., 8 p.m. Ballot for the Election of Fellows. 1. Dr. Armstrong and Dr. Miller, "The Decomposition and Genesis of Hydrocarbons at High Temperatures." (I.) "The Products of the Manufacture of Gas from Petroleum." 2. Mr. H. Brown and Dr. G. H. Morris, "The Non-crystallisable Products of the Action of Diastase upon Starch." 3. Mr. H. B. Dixon, "The Decomposition of CO_2 at High Temperatures." 4. Mr. B. Blount, "The Cause of the Decrepitation in Samples of so-called Explosive Pyrites." 5. Mr. T. Turner, "The Influence of Silicon upon the Properties of Cast-iron."

Historical, 11, Chandos-street, W., 8 p.m.

Numismatic, 4, St. Martin's-place, W.C., 7 p.m. Annual Meeting.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Anniversary.

FRIDAY, JUNE 19...United Service Institution, Whitehall-yard, S.W., 3 p.m. Major Cooper King, "The best system of Tactics for encountering very superior forces of a fairly armed and undisciplined but resolute enemy, such as the Arabs in the Soudan."

Philological, University College, W.C., 8 p.m.

Journal of the Society of Arts.

No. 1,700. Vol. XXXIII.

FRIDAY, JUNE 19, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One Hundred and Thirty-first Annual General Meeting, for the purpose of receiving the Council's Report and the Treasurer's statement of receipts, payments, and expenditure during the past year, and also for the election of officers and new members, will be held, in accordance with the Bye-laws, on Wednesday, the 24th June, at 4 p.m.

(By order of the Council)

H. Trueman Wood,
Secretary.

CONVERSAZIONE.

Members are reminded that Saturday next, the 20th inst., will be the last day on which additional tickets for the Conversazione at the Inventions Exhibition can be purchased at the rate of 5s. each. Applications received at the Society's offices by the first post on the morning of Monday, the 22nd, will be considered as being in time, but after that time no tickets will be sold at less than 7s. 6d. each. On and after the 1st July the price will be 10s. a ticket.

The Council, however, reserve the right of stopping the sale of tickets or of raising the price, if it is found necessary, in order to restrict the number of visitors within reasonable limits.

Tickets will only be supplied to persons presenting members' vouchers, (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter, a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase.

The issue of tickets will be strictly confined to members of the Society and their friends, and to those specially invited by the Council.

There will be no admission to the Exhibition on this evening except by special ticket, and no tickets can be purchased at the Exhibition.

INTERNATIONAL INVENTIONS EXHIBITION SEASON TICKETS.

The Executive Council of the International Inventions Exhibition have consented to allow Members of the Society of Arts the privilege of purchasing Season Tickets for the Exhibition at half-price (10s. 6d.) Any member desiring to avail himself of the privilege can obtain a ticket by applying to the Secretary, and remitting the price, 10s. 6d. Each member will only be allowed the privilege of purchasing a single ticket on these terms, which will be a personal admission, not transferable. It will be understood that all applications must be accompanied by the above-named remittance, and that tickets at the reduced rate can only be obtained from the Secretary of the Society.

FINANCIAL STATEMENT.

The following statement is published in this week's *Journal*, in accordance with sec. 40 of the Society's Bye-laws :—

TREASURERS' STATEMENT OF RECEIPTS, PAYMENTS, AND EXPENDITURE FOR THE YEAR ENDING MAY 31ST, 1885.

Dr.

	£ s. d.	£ s. d.
To Cash in hands of Messrs. Coutts and Co., 31st May, 1884	537 1 2	
Do. in hands of Secretary	23 8 1	
		560 9 3
,, Subscriptions received during the year from Members and Institutions in Union	6,474 1 0	
,, Life Compositions	525 0 0	
		6,999 1 0
,, Transferred from Deposit with Messrs. Coutts and Co. to meet special charges under Howard and other Trusts		200 0 0
,, Dividends and Interest		654 15 6
,, Ground Rents		176 5 0
,, Examination Fees		262 10 9
,, House and Office (receipts for gas, &c.)		38 6 0
,, Advertisements		1,164 12 11
,, Amount received from W. Westgarth, Esq., for a Prize		25 0 0
,, Do. Do. from Lady Siemens for Prize in connection with the Health Exhibition		20 0 0
,, Cash received on account of carriage of exhibits to Exhibition of Union Centrale des Arts Décoratifs, Paris		2 15 0
,, Sales—		
Cantor Lectures	19 17 6	
Examination Papers	2 10 2	
Journal	145 6 10	
Public Health Conference Reports	1 11 6	
Spoiled Post-cards	1 3 2	
Transactions	1 10 0	
Water Supply Conference Reports	18 17 7	
		190 16 9
		£10,294 12 2

Cr.

	£ s. d.	£ s. d.
By House and Premises :—		
Rent, Rates, and Taxes	362 3 8	
Insurance, Gas, Coal, House expenses, and charges incidental to ordinary meetings	391 18 0	
Repairs and Alterations	41 0 7	
		795 2 3
,, Office :—		
Salaries and Wages	2,039 7 2	
Stationery, Office Printing, and Lithography	308 14 1	
Advertising	61 7 9	
Postage Stamps, Messengers' Fares, and Parcels	228 2 7	
		2,637 11 7
,, Library, Bookbinding, &c.		129 11 1
,, Conversazione		398 16 5
,, *Journal*, including Printing, Stamps, and Distribution		2,619 10 0
,, Advertisements (Agents and Printing)		656 8 7
,, Examinations		330 0 10
,, Medals :—		
Albert (1883 and 1884)	43 8 7	
Society's	21 3 3	
		64 11 10
,, Prizes (awards and expenses) :—		
Fothergill	39 18 0	
Owen Jones	5 11 0	
North London Exhibition	20 0 0	
Shaw	20 0 0	
Siemens	20 0 0	
Stacy	20 0 0	
Stock	20 0 0	
Trevelyan	100 0 0	
Westgarth	1 13 3	
		247 2 3
,, Cantor Lectures		265 16 6
,, Howard Lectures		100 0 0
,, Juvenile Lectures		24 19 0
,, Sections :—		
Applied Chemistry and Physics	72 1 0	
Foreign and Colonial	61 0 0	
Indian	79 7 6	
		212 8 6
,, Water Supply Conference		37 16 8
,, Committees :—		
Collisions at Sea	49 17 6	
Education Code	2 9 10	
General expenses	25 9 10	
		77 17 2
,, Exhibition of Union Centrale des Arts Décoratifs, Paris (carriage of goods, &c.)		22 8 0
,, Annuity to Mrs. Le Neve Foster		100 0 0
,, Investment in Reduced 3 per Cent. Stock of Life Compositions of the year	525 0 0	
,, Do. do. from income of the year	200 0 0	
		725 0 0
		9,445 0 8
,, Cash in hands of Messrs. Coutts and Co., May 31st, 1885	827 6 5	
Do. in hands of Secretary	22 5 1	
		849 11 6
		£10,294 12 2

Liabilities.

	£ s. d.	£ s. d.
To Tradesmen's Bills	492 4 11	
,, Rates	50 0 0	
,, Examiners' Fees	107 2 0	
,, "Westgarth" Prizes	1,200 0 0	
,, Do. do.	25 0 0	
,, Sections:—Foreign and Colonial, Applied Chemistry, and Indian	180 0 0	
,, Accumulations under Trusts	246 9 6	
,, Balance of Money received from Union Centrale des Arts Décoratifs, Paris	20 7 0	
		2,321 3 5
Excess of Assets over Liabilities		11,581 15 2
		£13,902 18 7

Assets.

	£ s. d.	£ s. d.
By Society's Funds invested in—		
Reduced 3 per Cent. Stock, £6,721 4s. 1d., worth, on 31st May, 1885, £6,704 8s., less £757 15s. 11d, reserved to meet Trusts No. 6, 7, and 8 below	5,946 12 1	
£217 Great Indian Peninsula Railway 4 per Cent. Debenture Stock, worth on 31st May, 1885	225 13 7	
£1,000 Queensland 4 per Cent. Bonds, worth on 31st May, 1885	1,010 0 0	
		7,182 5 8
,, Subscriptions of the year uncollected	705 12 0	
,, Arrears, estimated as recoverable	275 0 0	
		980 12 0
,, Property of the Society, including Barry's Pictures and Lease of House		2,000 0 0
,, Advertisements on the Books, due and in course of execution*		1,490 9 5
,, Cash in hands of Messrs. Coutts and Co., 31st May, 1885		827 6 5
,, Ditto on Deposit		1,400 0 0
,, Ditto in hands of Secretary		22 5 1
		£13,902 18 7

* A portion of this sum is liable to charges for printing.

Investments Standing in the Name of the Society.

Ground Rents on Tyssen-Amherst Estate	£4,590 0 0
Consols	425 8 9
New 3 per Cents	388 1 4
Reduced 3 per Cents	6,721 4 1
Metropolitan Railway 4 per Cent. Perpetual Preference Stock	500 0 0
Oude and Rohilcund Railway 5 per Cent. Guaranteed Stock	2,150 0 0
Bombay and Baroda do. do.	2,450 0 0
Canada 4 per Cents	423 0 0
India 4 per Cents	105 18 7
Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock	2,170 0 0
Queensland 4 per Cent. Bonds (Redeemable in 1915)	1,000 0 0
Cash on deposit with Messrs. Coutts and Co.	1,400 0 0

Trust Funds included in the Above.

1. Dr. Swiney's Bequest	£4,500 0 0	Invested in ground-rents, and chargeable with a sum of £200 once in five years.
2. John Stock Trust	100 0 0	Consols, chargeable with the Award of a Medal.
3. Benjamin Shaw Trust for Industrial Hygiene Prize	133 6 8	,, ,, ,, Interest as a Money Prize.
4. North London Exhibition Trust	192 2 1	,, ,, ,, ,, ,,
5. Fothergill Trust	388 1 4	New 3 per Cents. chargeable with the Award of a Medal.
6. J. Murray, in aid of a Building Fund	54 18 0	Reduced 3 per Cent. Stock.
7. Subscriptions to an Endowment Fund	562 2 2	
8. Dr. Aldred's Bequest	140 15 9	
9. Thomas Howard's Bequest	500 0 0	Metropolitan Railway 4 per Cent. Perpetual Preference Stock.
10. Dr. Cantor's Bequest	4,600 0 0	Bombay and Baroda and Oude and Rohilcund Railway 5 per Cent. Guaranteed Stock.
11. Owen Jones Memorial Trust	423 0 0	Canada 4 per Cent. Stock, charged with the Award of Prizes to Art Students.
12. Mulready Trust	105 18 6	India 4 per Cent. Stock, the Interest to be applied to keeping Monument in repair and occasional Prizes to Art Students.
13. Alfred Davis's Bequest	1,953 0 0	Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock.
14. "Westgarth" Prizes	1,200 0 0	On Deposit with Messrs. Coutts and Co.
15. Accumulated Interest on Trust Funds	200 0 0	

The Receipts of the Society set forth above have been credited by Messrs. Coutts and Co.

The Payments set forth above have been made by authority of the Council.

The Assets, represented by Stock at the Bank of England, and securities, cash on deposit, and cash balanse in hands of Messrs. Coutts and Co., as above set forth, have been duly verified.

Owen Roberts, } *Treasurers.*
W. R. Malcolm, }

J. O. Chadwick, *Auditor.*

H. Trueman Wood, *Secretary.*

Society's House, Adelphi, 12th June, 1885.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The following is a list of Jury R for Division II. of the Exhibition—Music :—

Group 32.—*Instruments and Appliances constructed or in use since* 1800.

Group 33.—*Music Engraving and Printing.*

H.R.H. the Duke of Edinburgh, K.G. (chairman); Luigi Arditi; R. H. M. Bosanquet; J. Frederic Bridge, Mus. Doc.; Alfred Gibson; Thomas Harper; Charles Harrer, M.D.; M. Hawkins; Professor George Horton; William Huggins, D.C.L., F.R.S.; A. C. Köhler; the Earl of Lathom; J. A. Fuller Maitland; August Manns; Dr. Martin; Samuel Millar; Walter Parratt; C. H. Hubert Parry, Mus. Doc.; Ernst Pauer; E. J. Payne; Eugenio Peruzzi; H. W. Petherick; Dr. William Pole, F.R.S.; George Curtis Price; W. S. Rockstro; C. V. Stanford, M.A.; W. H. Stone, Mus. Doc.; Franklin Taylor; E. H. Turpin.

Amongst the recent additions to the Historic Loan Collection is Queen Elizabeth's Lute (lent by Lord Tollemache of Helmingham), which was left by the Queen, in 1584, at Helmingham-hall, Suffolk, where it has been preserved until the present day. The Lute is in fine condition, and bears the maker's name, "Joannes Rosa Londini Fecit. In Bridwell, the 27th of July, 1580." A collection of early manuscripts has also been received from the Stiftsbibliothek of St. Gall, including the celebrated copy of Notker's German translation of the Psalms, and the Antiphoner traditionally said to have been brought from Rome to St. Gall in the 8th century. Collections of portraits in oil have been received from the Royal Society of Musicians and the Bodleian Library. The decorated Spinet made for Queen Christina is lent by Lord de Lisle; and autograph letters of Mendelssohn, Franz, &c., Beethoven's Will, and many other manuscripts have also been added to the collection.

THE TRADE IN FEATHERS.

By P. L. Simmonds.

The fashion for wearing feathers has had a much longer reign than most other fashions with ladies, and hence the trade in feathers and birds' skins has now attained enormous proportions. When we find the annual value of the imports into this country alone of feathers exceeding two millions sterling, the application, preparation, and subsequent retail sales must necessarily be very profitable to those concerned. The largest quantities come from India, Asia, and Africa, but subsidiary supplies also reach us from America. In the present remarks I shall confine myself to the land birds, leaving the aquatic ones possibly for a future notice.

The average annual importation into this country and France of small foreign birds of bright plumage is no less than a million and a half. They come mainly to England for distribution. We import about a quarter of a million humming birds yearly. At a public sale in the autumn of last year, besides the loose feathers, 147,386 bird skins were disposed of during the two days' sale, among which were no less than 44,381 green or Amazon parrot (*Chrysotis amazonica*) and other species.

The following figures show the importance of the trade in feathers in this country—specifying the annual imports for nine years :—

	For Birds.	Ornamental Feathers.
	£	£
1875	126,177	713,199
1876	109,045	778,477
1877	109,041	873,192
1878	91,679	1,002,902
1879	80,238	1,146,211
1880	107,554	1,367,128
1881	127,374	1,322,255
1882	144,694	1,957,840
1883	155,240	2,011,926

We re-export about half of the ornamental feathers as follows :—

	£
1879	491,140
1880	660,931
1881	723,187
1882	1,003,278
1883	1,009,123

France and the United States take half of these exports.

In a paper which I read before the Society in February, 1876, on "The Trade in Ostrich Feathers" (*Journal*, vol. xxiv. p. 225), I brought down the statistics of our imports to 1874, and it is interesting to trace the subsequent rapid augmentation which has resulted from ostrich farming, and the domestication of the ostrich in South Africa since that period. The direct imports of these feathers from South Africa are specified in the returns. In contrast with these, I may place the imports from Northern Africa, which I collect from the countries of import, viz., Malta, Egypt, Tripoli, and Morocco.

	South Africa.	North Africa.
	£	£
1875	293,866	94,164
1876	360,572	67,481
1877	400,926	61,180
1878	590,372	33,162
1879	717,056	45,949
1880	959,079	47,651

	South Africa	North Africa.
	£	£
1881	973,774	28,183
1882	1,421,337	49,268
1883	1,425,681	86,943

Aden is an *entrepôt* for ostrich feathers, from 7,000 lbs. to 8,000 lbs. being exported annually; half of these are received from Berbera.

Mr. R. H. Elliott, in a paper read not long ago before the East Indian Association, called attention to the large exports from the port of Madras, which are chiefly sent to Hong Kong and Singapore, and argued that the bright plumaged birds would soon be exterminated.

The following were the shipments thence in the last three years:—

FEATHERS.

	lbs.	Value.
1881	122,175	£1,662
1882	105,515	1,998
1883	167,750	2,666

BIRD SKINS.

	Quantity.	Value.
1881	82,400	£1,998
1882	98,300	2,098
1883	11,275	166

But if we take the whole of our imports from India, they form a much larger aggregate:—

	£		£
1871	21,840	1878	25,775
1872	29,149	1879	19,482
1873	38,836	1880	22,164
1874	38,484	1881	24,082
1875	37,197	1882	33,658
1876	23,587	1883	66,455
1877	18,563		

The following figures, showing the total exports of feathers from British India, prove the importance of the trade. They are for the years ending March in each year:—

Year.	lbs.	Value. £
1879	55,000	21,933
1880	41,279	18,618
1881	65,433	26,944
1882	67,164	28,966
1883	89,839	30,425
1884	104,621	47,639
1884 (Six months to Sept. 30.)	46,487	41,352

From India we receive chiefly the blue jay, jungle cocks, orioles, trayopans, kingfishers (*Alcedo Bengalensis* and other species), peacocks' feathers, and pelicans' feathers. Of the last named there is a terrific slaughter carried on during the moulting season in Cambodia. They are taken in enclosures, and one to two thousand killed nightly for about a week. The greyish feathers from each wing, and the black feathers at the extremities are plucked and tied up in bundles, and they are in the East chiefly made into fans. These feathers are in request in Europe, as they take dyes readily.

The feathers of the little egret heron, and of the *Ardea alba*, are much esteemed for ornament. To show the large employment of these feathers, I may state that at a feather sale in January, 1876, the feathers sold, on a moderate calculation of twenty to each bird, involved the slaughter of 9,700 herons, all from India. Then we have the feathers of the marabou and adjutant storks from India. The former has a long range of latitude in Western Africa, extending from Senegal to Angola. The feathers of the greater and lesser adjutant are scarcely equal to those of the marabou. The gigantic stork or adjutant is extremely common in northern India, more especially in Bengal, being well known in the larger towns as an efficient scavenger bird.

Peacock feathers, both from the body and the tail, seem in great request for feather trimmings. At a public sale in August, no less that 75 cases were sold, containing not only complete skins of the bird, but brilliant blue neck skins, wings, and body feathers, tail feathers, classified into eyes, swords, which are the brilliant metallic green feathers which border the tail at each side, and fish tails, the ordinary feather with the eye cut out. Peacock feathers are much employed in India as fans, brooms, picture cleaners, &c., which sell locally at 6d. to 1s. each.

Of the eighteen species of birds of paradise known, fourteen inhabit New Guinea and the adjacent islands, three Australia, and one only the Moluccas. The four true birds of paradise which form a well characterised group, belong solely to New Guinea and the adjacent islands. The other species are more rare. The best known are the great bird (*Paradisea apoda*, Lin.) known since the middle of the 16th century, found in the Aru islands, and the small emerald (*P. papuana*, Bechst), the plumage of the latter being used to decorate alike the head gear of eastern rajahs and western dames of fashion. The redbird has flowing side plumes of rich crimson instead of yellow. The king-bird is a little gem of exquisite plumage, having two slender wire-like shafts, nearly 6 inches long, protruding from the tail, each terminating in a broad emerald green spiral fish.

Birds of paradise must have been found by the Portuguese on their conquest of Malacca in 1511, brought to that emporium by the Malay and Javanese merchants for the markets of China. At all events they must have seen them on their arrival in the Moluccas in the same year or the beginning of the following. But the earliest account we have of them is that given by Pigafetta, who was at the Moluccas ten years after the Portuguese had reached them. His description, taken from the original manuscript published in 1800, is as follows:—

"They gave us also for the King of Spain two most beautiful dead birds. These birds are about the size of thrushes. They have a small head and a long bill; legs fine as a writing quill, a palm long.

They have no wings, but in their stead long feathers of variours colours like great plumes. The tail resembles that of the thrush. All the feathers except those of the wings are of a dark colour. They never fly except when the wind blows. They told us that these birds came from the terrestrial paradise and they called them *burung diwata*, that is 'bird of God.'"

It is probable from this account that the birds of paradise sent by the King of Tidor, one of the five Moluccas, to Charles V., was not the great emerald bird with which we are most familar, but one of those which are natives of the Moluccas. At present the principal emporium for these birds in the East is the Aru Islands, and to the west, Batavia and Singapore; they are brought to the two last ports by the prahus of the Bugis of Celebes. We obtain our supply by way of Holland, and they cost from 20s. to 25s. each at first hand, according to quality. In 1872, 3,000 of these bird skins were shipped from the port of Dobbo in the Aru Islands.

The delicate feather sprays of the osprey or fish hawk (*Pandion halioetus*), of a light yellowish-brown or snowy white, are largely used in making aigrettes.

Prodigious quantities of the feathers of the Impeyan, argus, and other Indian pheasants are also received. Even in Leadenhall market the plumassier will purchase the freshest common pheasants for their plumage; they are skinned and dressed for ladies' hats, and the carcases of the birds sold cheap.

If we turn to South America, we find that there is a demand for the feathers of the American ostrich, as it is called, the *Rhea Americana*, which are known in commerce as "vulture feathers." In 1865, there was shipped from Buenos Ayres 153,330 lbs. of these feathers, valued at £38,498. The quantity shipped later from Buenos Ayres was in—

	Kilos of 2⅛ lbs.
1871	31,177
1872	73,132
1873	69,202
1874	59,454

Most of these go to France, but our imports were to the value of £8,422 in 1875, £10,735 in 1876, £4,520 in 1877, and the imports have now dropped to about half this quantity.

The feathers of the male bird realise more than those of the female.

The tail feathers of the golden eagle (*Aquila canadensis*) are used by the North American Indians for head ornaments. The yellow flicker (*Colaptes auratus*) and other gaudily arrayed summer birds yield their plumage for ornamenting dresses. The feathers of the Australian emeu are of a brown colour, fine but brittle. The plumage near the tail, however, is long and graceful. The feathers are dyed almost every shade, and are now much used for trimming and ornament. From Victoria these feathers, to the value of £3,187, were shipped in 1883, chiefly to the United Kingdom.

The quantity of these feathers obtained in Uruguay, in 1875, was 92,400 lbs.; but this fell, in 1877, to 44,000 lbs., valued at £20,000. This decrease arose from several causes. First, the indiscriminate slaughter by the hunters, not only of the birds, but of their eggs and young; second, the extension of the cattle; and, lastly, a Government decree, in 1877, forbidding the chase of the bird under heavy penalties, and encouraging production by offering a premium to the first person who should produce a certain number of birds in a domesticated state. This decree had the effect of reducing the total production of the feathers from the chase by two-thirds.

A great many farmers have now seriously undertaken the work of domesticating and raising the birds, so as to obtain the feathers at certain times. It is thought that, in a few years, this will lead to increased quantity and improved quality, the feathers plucked by the hand being said to be finer and more downy. Fine feathers, in packets, fitted for the European market, are valued at about 12s. per pound; and they fetch, in France, 16s. to 18s. a pound. They are nearly all sent to Havre; a few stray cases may occasionally be shipped to New York.

About £500 worth of feathers and bird skins are annually brought to Cayenne, including tufts of the heron, skins of the rapapa, the turkey sultan, and varieties of the humming birds. From South America also came the red cardinals, the blue crupus, and many other birds of lustrous plumage.

From the feathers of *T. resplendens* and other trogons, the mosaic pictures of the Mexicans were made. One of these, most delicately and beautifully executed, containing many figures, is now in the Ashmolean Museum, at Oxford, and is there said to be made of humming birds' feathers. The subject is "Christ fainting under the Cross." The whole picture is about the size of the palm of the hand, and the figures are barely half an inch in height.

The above cited facts and figures will convey some idea of the importance of the commerce in feathers and bird skins chiefly for personal adornment.

COLOUR-BLINDNESS IN THE MERCANTILE MARINE.

By Jabez Hogg, M.R.C.S.

A return of the results of the colour-blind test examinations of candidates for masters' and mates' certificates in the Mercantile Marine Service has been presented to Parliament, on the motion of Mr. Talbot.

The colour-test examination was, on the representation of the medical profession, established by the Board of Trade eight years ago, in May, 1877. Its value soon became manifest to those in authority, and soon afterwards, in 1880, it was made compulsory

upon all masters and mates to undergo an examination, and obtain a certificate of ability to distinguish colours, before proceeding to a further examination in navigation and seamanship. It was also extended to all persons about to enter the Mercantile Marine, as a means of satisfying themselves as to their fitness to enter the service at all; and for the certificate given a small charge of one shilling is made.

Failure to pass in the colour-test was equivalent to that of failure to pass the ordinary examination in navigation and seamanship, that is, it prevented candidates from obtaining the higher certificates of mate and master. This regulation was found to be unduly prejudicial to those who had already been some years in the service; and in March, 1880, a modified mode of procedure was adopted. The candidate already in possession of a certificate of competency of a lower grade, and wishing to procure one of a higher grade, is now permitted to do so; and if not successful, after two or three trials, in passing the colour-test, a certificate is granted, but the examiner writes across it—"the holder has failed to pass the examination in colours." This no doubt often has the effect of preventing the person from obtaining employment, but it is only right and just that shipowners should be in a position to protect themselves in such a case.

It is a matter of regret that the colour-test examination has not been made obligatory upon pilots and men on the "look out," as well as masters and mates. Pilots have the right to navigate all ships as soon as they sight our coasts; nevertheless, they are wholly exempted from the operation of so useful and valuable a test of their fitness for the task. This has arisen from the circumstance, that the pilot service is under the control of the Trinity House.

This will be regarded as a serious omission, as there cannot be a doubt that collisions at sea occur more frequently when pilots are in charge off our coasts, than when ships are out at sea, and in charge of the master or captain. If the compulsory colour-test examination were extended to pilots, a large number would no doubt be found unfit for the service, by reason of their being colour-blind.

In an appendix to the report many typical cases of complete and incomplete colour-blindness are given "illustrative of the danger of employing on the look-out at sea, and without any safeguard, persons who have an imperfect appreciation of colour." But, by an unaccountable oversight, the proportion or percentage of the colour-blind to the total number of persons examined has been altogether omitted. In the former report, that of 1877 and 1878, it was given at ·43, or rather less than half per cent., a much smaller per-centage than that of any other class of men, indeed, as small as that of women. The subjoined summary shows the mistakes made by the 86 candidates in naming colours.

Colours of Cards, Wools, or Glasses.	Green.	Red.	Yellow.	Blue.	Other Colours.
Green described as	—	79	16	19	13
Red	24	—	0	3	3
Yellow	9	38	—	1	2
Blue	45	2	1	—	4
Black	4	2	—	—	3
White	3	1	—	—	

After due consideration of the various modes of conducting the examinations by other nations, the Board of Trade came to the conclusion "that there was nothing in the colour-tests, or mode of applying them, as adopted by other countries, which, for practical purposes, is an improvement upon those in use in this country." But while it is thought to be undesirable to make any alteration in the method of applying the colour-test, or making it more searching or elaborate, in the public interest it is certainly desirable to apply it more generally. It does not admit of a doubt that an examination in colours is needed not only for officers, but for pilots, and for men on the "look out." This remark applies with equal force to all officers, masters of ships, who obtained certificates before the colour-test examination was instituted or made compulsory, and who, from colour-blindness, may be unwittingly and ignorantly risking the lives of crews and passengers, and yearly adding to the number of lost ships. But for the great apathy displayed by shipowners themselves, this, I believe, would have been done long ago. Shipowners, however, still affect a disbelief in the danger associated with colour-blindness. Ignorance, and a settled determination to reject all proof in this particular, stands, as usual, in the way of adopting preventive measures.

It is known to but comparatively few persons that colour-blindness affects the human race in different degrees, is hereditary, is an incurable physical affection, and is chiefly confined to the male branch of families; the average per-centage being $3\frac{1}{2}$ to 4 per cent. of males, and only 0·5 per cent. of females. A selected instance or two will serve to impress this fact upon the memory. In a family of seven children, four sons and three daughters, the four sons are more or less colour-blind. The defect is inherited from the grandfather, through the mother, but neither the mother nor any female member of the family is colour-blind. In a family of five, three sons and two daughters, the three sons inherit colour-blindness through their father and grandfather, while the two daughters, and, indeed, the whole of the female branch of the family, are free from any colour defect.

My object in directing attention to the hereditary nature of colour-blindness is that of enforcing the duty upon parents—one they owe to themselves and

to their children—of making due inquiry into every peculiarity or defect of sight which may have constituted a family failing, before yielding to the wish of a child for a seafaring life. The inability of a boy to distinguish colours in common use should at once determine the question of his taking to the sea at all.

In conclusion, I would say, in answer to the question put by the Assistant-Secretary of the Marine Department of the Board of Trade, as to what more can the Board do to increase the efficiency of the colour-test; by all means make the examination compulsory upon all officers, pilots, and men on the "look-out;" if you do not, then, in the event of loss of life and property by collisions at sea, public opinion will naturally condemn the Board for remaining a party to a laxity of the colour-test examination, and which requires to be more stringently enforced and applied than it is at present.

SILK HARVEST AT BOURNABAT.

By William Cochran.

Feeling assured that the successful revival of an ancient industry, in any country, cannot fail to possess some degree of interest for the members of the Society of Arts, I venture to send a few notes regarding what I have seen in this part of Asia Minor during the past two months or so, connected with the resuscitation of silk-farming by Mr. John Griffitt, a distinguished Englishman, formerly vice-consul for the United States at Smyrna.

As a preliminary remark, it may be mentioned that, in common with other sericicultural countries, this industry in Turkey, during the past thirty-five years, suffered from a succession of maladies which overtook the silkworms. In Asia Minor, a formerly robust trade dwindled; the silk mills of Smyrna had to be closed for lack of the raw material; the work-people had to find other employment; the peasantry lost a remunerative source of gain during a period of the year when other means of earning a little money were scarce, or out of their reach; and, as a result, the silk revenue of Turkey, and certain bondholders in England and elsewhere, suffered.

Having heard of Mr. Griffitt's life-long labours to restore this almost extinct industry, and having received from him a cordial invitation to visit his establishments near Smyrna, in the hope that I might, by personal inspection, be able to use the information so gained for the benefit of British colonists in New Zealand, and other possessions, I went. Taking passage in the Cunard steamer *Sidon*, from Liverpool, on the 27th February of the present year, I arrived in the Bay of Smyrna on the 14th March, and proceeded, by rail, to Bournabat, a vllage about four miles distant, where I was heartily welcomed and entertained by Mr. and Mrs. Griffitt during the period of my stay.

Although I had arrived about a fortnight before the commencement of the silk-farming operations of the season, there were important steps to be taken in some of the adjacent as well as more distant villages, so as to place the sericiculturists there on as near a footing of equality as possible with the more favoured, because local, silk farmers of Bournabat. These steps consisted in the distribution of silkworms' eggs (graine), of previously ascertained healthiness, to all who desired to conduct an education, and were able to show that they possessed reasonable facilities for doing so. Accordingly, on the 16th March and on subsequent occasions, I accompanied Mr. Griffitt to the villages of Narlique, Hagelar, Konkloudjah, Chobarrissa, and to the more important towns of Magnesia, Nymphis, and elsewhere. In these places levees were held at the houses of prominent natives, applications for graine were invited, and the requirements of applicants were supplied to the extent of from half an ounce to six ounces of eggs to each, according to his or her ability to educate, special care being exercised by cross-questioning to discover the extent of their command of mulberry trees. The terms upon which the graine was supplied were—no charge for the eggs, but an undertaking on the part of the applicant to hand over to Mr. Griffitt or his agent at the proper time a fixed share of the resulting cocoons, the farmer finding all the labour, implements, and food for the worms, and promising to follow implicitly the instructions printed in the Greek language given him.

The distribution at Bournabat differed from that just described only in the circumstances that it occurred some days later, and applicants were supplied with eggs on somewhat easier terms, on account of there being no expense attending the transactions. Meanwhile the weather, hitherto genial with a temperature of 56° Fahr., had become cold, so that the opening of the mulberry buds was retarded for a few days and the incubations postponed. But this did not seem to be considered a disappointment, as it allowed a little longer time to the intending educators to complete their arrangements for a supply of leaves in cases where they were relying upon others.

Here it may appropriately be noted that the food used by Mr. Griffitt and his people for feeding their silkworms at every stage is the wild white mulberry leaf, which varies in size and shape from the small, deeply indented one of two inches long, to the handsome shapely form of nearly a foot in length. The best and largest kinds of the wild white mulberry are grafted upon similar stocks, and gradually improved from year to year, until some of the leaves attain the size of cabbage blades. The advantage claimed for feeding with the wild white mulberry is that the leaf is found to contain more nutriment in less bulk, consequently it is less watery than any of the cultivated varieties, and the risk to the worm of indigestion and the malady called "flacherie" much reduced. But the best proof of the soundness of Mr. Griffitt's practice in this important matter is to be found in his

success during past years, on the robust and entirely healthy condition of his worms, and in the splendid harvest he has obtained this season, to be alluded to further on.

To the whole process of sericiculture, as comprised within the limits of one season, the technical name of an "education" is given. The average period so occupied here is 62 days, as follows:—

	Days.
Time required between setting the graine to hatch, feeding the worms, their various moultings, and mounting the brushes to spin	40
Producing the cocoons consumes	3
Allow for laggards an additional	2
Transformations in the cocoons ere the moths issue	15
Pairing and depositing eggs	2
	62

It is of course quite possible to recommence the whole process of education at the end of the term, and by means of imported eggs obtain a second crop of silk. This is done by some, but in the present diseased state of foreign graine it is neither practised nor recommended by Mr. Griffitt, as the protracted plucking of the mulberry tree injures its health without sufficient compensation, and the silk obtained is weak and in every way inferior.

The breeds of worms educated by Mr. Griffitt during the present season have been three in number, namely:—1st. The Bagdad white race; 2nd, the indigenous yellow race; and 3rd, hybrids between the two.

The Bagdad White Race.—This beautiful and robust race, the largest hitherto educated in Asia Minor, was brought from Bagdad some years ago. On arrival the breed, unfortunately, showed a large amount of corpusculous disease, and all idea of raising stock from it was abandoned. Later, however, it was determined to give the eggs a further trial by an education on Pasteur's cellular system. By this tedious, expensive, yet thoroughly effective plan, about half an ounce of eggs were treated, resulting in 7,000 moths of both sexes capable of being paired. From these the eggs of only 200 moths were carefully selected and again reared cellularly, yielding but 42 moths absolutely free from disease. This small but healthy colony of renovated Bagdad insects formed the nucleus of the present beautiful race which bids fair to outstrip all other Asiatic kinds in the size, weight, and value of the cocoons they spin. As offering an illustration of what lies in the future for this class of silk, I may mention that the regeneration of the Bagdad white breed will prove of great benefit to the fishermen who ply their calling in the Gulf of Smyra and others. These men hesitate at no expense when demanded for their nets, and use the best and strongest silk in their manufacture, whenever the cost ceases to be altogether prohibitory. The Bagdad race of silkworms yields the strongest filament known, and as, under Mr. Griffitt's careful and unwearied treatment, the annual yield may be expected quickly to increase and the article to become cheaper, the fishermen of Smyrna and of the Greek Archipelago are already heaping blessings upon the head of their benefactor.

The Indigenous Yellow Race.—The local history of this smaller and yet beautiful and valuable race is as follows:—Eight years ago Mr. Griffitt received a pinch of graine from M. Rolande, an eminent and well-known sericiculturist of Switzerland, for experimental purposes. During the first year the race answered fairly well; the second season proved disappointing; while the third was an absolute failure. On the last occasion a cellular education was undertaken, followed—as such educations must be—by success. A thorough purging from disease was the reward of this experiment, and the breed is now largely and remuneratively reared by Mr. Griffitt and his friends.

The Hybrid Race.—It would have been impossible for any scientific sericiculturist to contemplate for any length of time the cocoons produced by these two splendid races, without the thought arising that a hybrid between them might, by uniting the merits of both, yield a silk of surpassing beauty. The essay was made with an important gain in the weight of the cross worm thus produced; the average of which is 3·91 grammes as compared with the average weight 3·77 of the yellow race. The silk also proved of the finest quality.

The Cross Black Race may be considered a freak of nature, and may occur in any education of hybrid worms. They are considered very vigorous, are locally known as "arapenes" (negresses), or "kalogrees" (nuns), and their average weight, 4·1 grammes, is high, as they eat long and voraciously. Out of a hatching of 60,000 worms, only 82 of this cross black race appeared, and these, having been separated and reared by themselves, gave the following return:—82 worms produced 1 imperfect cocoon, 3 double cocoons, 39 female cocoons, 37 male cocoons; in all 79 cocoons. The average weight of the male cocoons was 2·26 grammes, and that of the female 2·73 grammes.

Brought into a focus for comparison, the average weights of the worms of the four varieties, carefully noted immediately before they mounted their brushes to spin, figured as follows:—The Bagdad white, 5·66 grammes; the indigenous yellow, 3·77 grammes; the white hybrid, 3·91 grammes; the black hybrid, 4·1 grammes.

Of the above three races, an experimental education of $1\frac{1}{2}$ ounces of eggs was conducted in two upper chambers of Mr. Griffitt's residence. As this was an education having for its object the raising of a quantity of healthy graine for next season, rather than with a view to silk, the temperature of the rooms was purposely kept very moderate. The only period during which artificial heat was employed,

was at hatching, when the temperature was raised to and kept at 60°, a temperature, however, which a few days thereafter saw exceeded, in a natural way, to 65°, 70°, and 80°, by the increasing power of the sun. In the early stages of this education attention to the requirements of the worms occupied comparatively little time, but as they advanced in size and developed in voracity, the almost continuous labour of four persons scarcely sufficed, while, towards the end, a man and donkey were employed for several days, morning and evening, keeping up the supply of mulberry leaves from several miles distance. This circumstance, and my observations on subsequent occasions, clearly showed that an economically conducted sericicultural industry demands that all the mulberry trees required ought to be grown in immediate proximity to the nursery.

After the indispensible necessity of perfect cleanliness and suitable food supplied in a fresh yet dry condition, one of the most important points connected with rearing healthy worms is good ventilation and its necessary accompaniment, ample space. The rooms occupied by the $1\frac{1}{2}$ ounces of graine measured, one 23×17 feet, with five windows and four doors, and yielding 504 square feet of frame space upon which the worms were fed; and the dimensions of the other were 18×18 feet, with two windows and two doors, and possessing 432 square feet of frame space. Altogether the calico surface occupied by the worms at the time they commenced to mount the brushwood to spin their cocoons was 936 square feet, in rooms the ceilings of which were 12 feet above the floors. When it is recollected that the original $1\frac{1}{2}$ ounces of eggs, when laid down to hatch 40 days before, were amply lodged within the space of two square feet, it will be understood how rapid is the progress of silkworm growth, and it will be admitted how essential to their health and progress must be the cleanliness, pure air, and liberal accommodation Mr. Griffitt accords them.

In every education there are a few ambitious pioneer cocoons, and there are also some laggards. When the former evince by their restlessness, ceasing to eat, and by a swaying movement of the head that their long meal is over and their serious work about to begin, the sericiculturist arranges his previously obtained and prepared supply of pine branches or other brushwood in such a manner that the worms shall have easy access to them, and not have far to travel. Mounting the brushes nearly always commences in the morning, and the worm starts to spin and weave at once as soon as it has found a suitable nook. Making due allowance for the laggards, called by the French *retardaires*, the education so far should have terminated, and the cocoons have been completed on the 45th day. It is during the following 15 days that the principal anxiety of the scientific educator lasts, for, although his crop of silk for the season is now safe, he cannot yet say what his prospects for the future may be, as he is still in ignorance whether disease is present or not. At this period of solicitude the "friend in need" appears. The sturdy pioneer worm has developed into the welcome pioneer moth. It gallantly issues from its cocoon some days in advance of the others; it performs its appointed duties, then yields its body for microscopic examination, and thus enables the shrewd observer to form an opinion regarding the presence or absence of disease, and to take immediate steps accordingly.

As might have been anticipated, the harvest of cocoons at Bournabat, and wherever Mr. Griffitt's graine had been distributed this spring, was of the most gratifying description. The small experimental hatching of $4\frac{1}{2}$ ounces yielded 60,000 worms, every egg having incubated, and each worm arriving at maturity and spinning its cocoon untouched by any malady. The result was the magnificent and unprecedented return of 61 okes, or 78 kilogrammes, equal to 174 lb. avoird. per ounce of eggs laid out to hatch. While this may be regarded as an exceptional harvest in the sense of having had no rival or even distant competitor hitherto, it is nevertheless simply the reward of scientific skill allied with a command of intelligent labour. Even the average yield of 133 lbs. per ounce obtained by some of Mr. Griffitt's peasants is a-head of the highest returns to which I have had access from other silk-producing countries, and shows beyond cavil how the influence of a master mind can be exercised for the good of a population.

Bournabat, near Smyrna,
29th May, 1885.

VARIATIONS IN METAL PRICES.

The *Metallarbeiter* remarks that metals have in most cases experienced a reduction in value of late years, this depreciation being attributed in some measure to the cheaper methods of obtaining metals, as well as to the discovery of new sources of mineral wealth.

The following comparative Table shows the approximate prices of various metals in December, 1874, and December, 1884.

	Dec. 1874. per lb.				Dec. 1884. per lb.		
	£	s.	d.		£	s.	d.
Osmium	71	10	0	....	62	0	0
Iridium	70	0	0	....	45	0	0
Gold	62	15	0	....	63	0	0
Platinum ..	25	7	6	....	21	7	6
Thallium....	23	17	6	....	4	15	0
Magnesium..	10	5	0	....	1	15	0
Potassium ..	5	0	0	....	4	0	0
Silver	3	17	6	..(in Hamburg)	3	7	6
Aluminium..	1	16	0	....	1	16	0
Cobalt......	1	14	0	....	1	2	0
Sodium	0	14	2	....	0	8	8

	Dec. 1874. per lb. £	s.	d.		Dec. 1884. per lb. £	s.	d.
Nickel......	0	11	0	....	0	3	1
Bismuth	0	8	1	....	0	8	1
Cadmium ..	0	7	1	....	0	4	0
Quicksilver..	0	2	0	.. (in London)	0	1	9
Tin	0	1	1	(in Berlin)	0	0	9
Copper	0	0	10		0	0	7
Arsenic	0	0	8	....	0	0	$4\frac{1}{2}$
Antimony ..	0	0	$6\frac{1}{4}$	(in Berlin)	0	0	5
Lead	0	0	$2\frac{3}{4}$		0	0	$1\frac{3}{8}$
Zinc........	0	0	$2\frac{1}{2}$		0	0	$1\frac{3}{4}$
Steel	0	0	$1\frac{3}{8}$	(in Upper) Silesia)	0	0	$0\frac{3}{4}$
Bar iron	0	0	$1\frac{1}{8}$		0	0	$0\frac{5}{8}$
Pig iron	0	0	$0\frac{7}{16}$		0	0	$0\frac{1}{4}$

Gold now ranks highest in value of all metals, the competition of osmium and iridium having been overcome. It is only by reason of improved methods of preparation that the latter have become cheaper, while their use has at the same time increased. Iridium is mixed with platinum in order to increase its strength and durability. The normal standards of the metrical system are made of platinum-iridium on account of its known immutability. In 1882, platinum stood 15 per cent. below its present value; but its increased employment for industrial purposes led to the subsequent improvement in price. Thallium has experienced a severe depreciation, on account of the economical process by which it is extracted from the residue of the lead chambers used in the manufacture of sulphuric acid. The use of this metal is mainly confined to experimental purposes. The fall in silver has arisen from increased production and diminished use for coinage.

Magnesium was scarcely of any industrial value prior to the fall in price now recorded. Improved processes for its treatment have successfully engaged the attention of scientific men, and it is now capable of being used as an alloy with other metals. The Salindres factory regulates the price to a certain extent, and its system of working is regarded as a guide in the various processes connected with this branch of industry. The manufacture of potassium and sodium will, it is expected, be more fully elucidated than hitherto, by means of researches made at Schering's Charlottenburg factory. The course of nickel prices illustrates the stimulus to economical production afforded by an increased consumption. This latter fact is principally due to the employment of nickel for coinage, as alloy for alfenide, &c. The use of cadmium is materially restricted by its relatively limited supply. Hitherto, its only source was in the incidental products of zinc distillation, but of late it has been attempted to bring it into solution from its oxide combinations. An increased employment of cadmium for industrial purposes is expected to follow.

Production in excess of demand has caused the depreciation recorded in tin, and various other metals not commented upon, this remark applying even to the scarce metals, arsenic and antimony. Even the better marks of Cornwall tin and Mansfield refined copper have had to follow the downward course of the market.

NEW CALEDONIA.

A report of the Italian vice-consul at Numea gives the following particulars respecting the present condition of New Caledonia. The climate of this island is very healthy, and in this respect it is very favourable for European colonists. The great drawback, however, is that the French have established a penal settlement here; the majority of the European population are convicts, and as the administration of this establishment grant a certain extent of land to each convict, which, after a time, becomes their property, it follows that, eventually, all the available land on the island will be owned by convicts or their descendants. The commercial operations of last year, as compared with those of 1883, show a considerable falling off, as will be shown by statistics which will shortly be published by the chamber of commerce. The exports and imports of New Caledonia in 1883 amounted in value to 15,822,461 fr. Notwithstanding the drawbacks previously mentioned, this island still offers a fair prospect for the employment of miners and farm labourers. The alluvial soil of this settlement is very fertile, and maize, rice, and other crops grow luxuriantly.

The mines of nickel, cobalt, antimony, and copper give employment to a large number of hands, the ore being taken to other parts by the small coasting vessels belonging to the island. Explorations for coal are being made at the present time, and it is anticipated that they will be followed by good results.

It may be mentioned that an inspector of the Bureau *Veritas* of Genoa has been lately sent out with a view of establishing an agency on the island, and, at the same time, to introduce into this colony Italian goods, and to investigate as to the prospects of this settlement becoming a field for Italian emigration and enterprise.

Obituary.

FLEEMING JENKIN, F.R.S.—Mr. Fleeming Jenkin, LL.D., Professor of Engineering in the University of Edinburgh, died in Edinburgh on Friday last, 12th inst., at the comparatively early age of fifty-two. Professor Jenkin delivered a course of five Cantor Lectures on "Submarine Telegraphy," in 1866, and from that time, he was intimately connected with the Society of Arts, although he did not become a member until 1882. His first work in connection with technical education, a subject in which he took

great interest, was done for a committee of the Society in 1868. His last communication was a paper on "Telpherage," which he read on May 14th, 1884, and for which the Council awarded him a silver medal. Professor Jenkin was born in Kent, March 25th, 1833, and received his education at Jedburgh, Edinburgh, Frankfort-on-Main, Paris, and Genoa; at the University of the latter place he took the degree of M.A. in 1850. He returned to England in 1851, and was apprenticed to Fairbairn's in Manchester. Seven years later the electrical testing of the first Atlantic cable was put under his charge, and after his election in 1859 as an Associate of the Institute of Civil Engineers, he gave evidence before the Royal Commission on Submarine Telegraphy. He was in 1865 elected a Fellow of the Royal Society, and in the same year was appointed Professor of Engineering in University College, London. Three years later he was appointed to the newly-instituted chair of Engineering in the University of Edinburgh. In 1877, he delivered two lectures before the Edinburgh Philosophical Institution on "Sanitary Houses," and these led to the formation of the Edinburgh Sanitary Protection Association. Similar associations have since been started in London (after the reading of a paper by Professor Jenkin before the Society of Arts), Glasgow, Brighton, Liverpool, Newcastle, Dundee, Cheltenham, Bradford, Wolverhampton, Bedford, Cambridge, and in the United States. He was the author of several books, and of a large number of papers and articles in the publications of scientific societies, and in various journals and reviews. His work entitled "Magnetism and Elecricity" was first published in 1873, and the eighth edition appeared in 1885. It was also translated into German and Italian.

General Notes.

Nickel Crucibles. — Crucibles of nickel have lately been adopted in some chemical laboratories, in the place of the silver ones generally used for melting caustic alkalis. They have given good results, and have the advantage, not only of being cheaper, but of being capable of resisting a higher temperature than the latter.

Bricks of Cork.—The waste cuttings of cork are now being employed for making bricks, which can be used for walls, impervious alike to heat or damp. The cork cuttings are reduced to powder in a mortar, and mixed with lime or clay, and from this composition the bricks are made in the usual way. When dried, they are capable of resisting a crushing strain of 3·6 kilogrammes per square centimetre (51·08 lbs. per square inch). They are very light, having a specific gravity of 0·35.

MEETINGS FOR THE ENSUING WEEK.

Monday, June 22...Geographical University, of London, Burlington-gardens, W., 8½ p.m.

Tuesday, June 23...Statistical, School of Mines, Jermyn-street, S.W., 4 p.m. Annual Meeting.

Anthropological, 3, Hanover-square, W., 8 p.m. 1. Exhibition of Objects of Ethnological Interest from Polynesia, by Lady Brassey. 2. Exhibition of Ethnological Objects from New Ireland, by Miss North. 3. Exhibition of Australian Implements, by Mr. Carl Lumholtz. 4. Mr. H. B. Guppy, "The Physical Characteristics of the Natives of the Solomon Islands." 5. Mr. Abraham Hale, "The Sakais." 6. Mons. Jean L'Heureux, "Notes on the Astronomical Customs and Religious Ideas of the Chokitapia or Blackfeet Indians." 7. Mr. Hyde Clarke, "Observations on the Mexican Zodiac and Astrology." 8. Mr. James Dallas, "The Primary Divisions and Geographical Distribution of Mankind."

Wednesday, June 24...SOCIETY OF ARTS, John-street, Adelphi, W.C., 4 p.m. Annual Meeting.

Geological, Burlington-house, W., 8 p.m. 1. Prof. John W. Judd and Mr. S. Collett Homersham, "Supplementary Notes on the Deep Boring at Richmond, Surrey." 2. Mr. W. W. Watts, "The Igneous and Associated Rocks of the Breidden Hills in East Montgomeryshire and West Shropshire." 3. Mr. R. Lydekker, "Note on the Zoological Position of the genus *Microchœrus*, Wood, and its apparent Identity with *Hyopsodus*, Leidy." 4. Mr. R. F. Tomes, "Observations on some imperfectly known Madreporaria from the Cretaceous Formation of England." Capt. F. W. Hutton, "Correlations of the Curiosity-Shop Beds, Canterbury, New Zealand." 6. Constantin Baron von Ettingshausen, "The Fossil Flora of Sagor in Carniola."

Thursday, June 25...Society for the Encouragement of Fine Arts, 9, Conduit-street, W. Morning Meeting.

Friday, June 26...Society for Promoting Industrial Villages (at the House of the Society of Arts), 10½ a.m. Conference.

United Service Institution, Whitehall-yard, 3 p.m. Mr. J. K. Laughton, "Notes on the last great Naval War (1793-1815)."

Quekett Microscropical Club, University College, W.C., 8 p.m.

Browning, University College, W.C., 8 p.m. Annual Meeting, Elections of Officers, &c. Mr. Cyril Leslie Johnson, "Browning in Relation to his Time."

Saturday, June 27...Physical Science Schools, South Kensington, S.W., 3 p.m. 1. Dr. Gladstone, "The Specific Refraction and Dispersion of the Alums." 2. Prof. J. A. Fleming (1) "A Form of Standard Daniell Cell, and its Application for Measuring large Currents;" (2) "Note on the Phenomenon of Molecular Radiation in Incandescent Lamps."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Journal of the Society of Arts.

No. 1,701. Vol. XXXIII.

FRIDAY, JUNE 26, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by permission of the Executive Council of the International Inventions Exhibition, in the Exhibition Buildings, on Friday, 3rd July next.

Invitations have been issued to members, each member receiving a card for himself, which is not transferable, and a card for a lady. In addition to this, tickets can be sold to members of the Society, or to persons introduced by a member.

These tickets will only be supplied to persons presenting members' vouchers (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

The price of tickets is now 7s. 6d. each. On and after the 1st July the price will be 10s. a ticket. Each ticket admits one person only.

The bands of the Grenadier Guards, and of the Pomeranian Hussars, also the Strauss Orchestra, will perform during the evening. Organ and pianoforte recitals will be given, and a concert in the Music-room.

A District Railway special train will leave South Kensington at 12.30 (*viâ* Charing-cross and Mansion-house), calling at all stations to Whitechapel.

A Metropolitan Railway special train will leave South Kensington (*viâ* Praed-street and Edgware-road).

The subway will be available for the use of visitors, and will remain open till the departure of the trains. Visitors to the Conversazione can obtain their tickets at the booking-office in the subway.

Light refreshments (tea, coffee, ices, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase.

The issue of tickets will be strictly confined to members of the Society and their friends, and to those specially invited by the Council.

There will be no admission to the Exhibition on this evening except by special ticket, and no tickets can be purchased at the Exhibition.

Proceedings of the Society.

ANNUAL GENERAL MEETING.

The Annual General Meeting for receiving the report from the Council, and the Treasurers' Statement of Receipts, Payments, and Expenditure during the past year, and also for the Election of Officers, was held, in accordance with the Bye-laws, on Wednesday last, the 24th instant, at four p.m., Sir FREDERICK ABEL, C.B., D.C.L., F.R.S., Chairman of the Council, in the chair.

The SECRETARY read the notice convening the meeting, and the minutes of the previous annual general meeting.

The following candidates were proposed, balloted for, and duly elected members of the Society:—

Allbless, Nowrojee Dadabhai, 34, Clanricarde-gardens, W.
Allen, William Henry, York-street Works, Lambeth, S.E.
Andain, Claude Edwin Hunt, 25, Lancaster-road, Bayswater, W., and 28, Martin's-lane, Cannon-street, E.C.
Barclay, Thomas, 17, Bull-street, Birmingham.
Barcroft, William, Redford, Moy, Co. Tyrone.
Bartrum, John Stothert, F.R.C.S., 13, Gay-st., Bath.
Bicker-Caarten, Chevalier Peter, 30, Northumberland-place, Bayswater, W.
Birkett, Robert, Lion-lodge, Brondesbury, N.W.
Bohm, William, West Spring-villa, Avenue-road, Acton, W., and 23, Old Jewry, E.C.
Boyle, John, Junior Carlton Club, S.W.
Cama, H. D., 171, Palmerston-buildings, E.C.
Cantwell, James F., 28, Paternoster-row, E.C.
Case, Edward, Stone-house, Stone-street, Maidstone.
Cayford, Ebenezer, 146, Leadenhall-street, E.C.
Clarke, Charles Leigh, Clareville, Cheetham Hill-road, Manchester.
Collins, John, 10, Friar-st., Doctors'-commons, E.C.
Cooper, Walter James, 48, Spencer-road, Dulwich-road, S.E.
Croft, G. Arthur Hutton, Travellers' Club, S.W., and Aldborough Hall, Boroughbridge, Yorkshire.
Cunynghame, Henry Hardinge, Hurlingham-lodge, Fulham, S.W.

Davis, Edward Pindle, 24, Park-crescent, Portland-place, W.
Dawson, Charles J., Barking, Essex.
Douglas, Robert K., British Museum, W.C.
Evans, Godfrey, 4, Rochester-terrace, Plymouth.
Harrison, Octavian Baxter Cameron, 76, Holland-road, Kensington, W.
Hosegood, Thomas William, St. George's Colour Works, George-yard, Whitechapel, E.
Jeffryes, H. Wyman, M.D., Salisbury Club, St. James's-square, S.W.
Leete, Joseph, South Norwood-park, S.E.
Lofthouse, J. Platt, Lansdown, Stroud.
Lowe, Charles, F.C.S., Summerfield-house, Reddish, near Stockport.
Macrory, Edmund, 7, Fig Tree-court, Temple, E.C.
Mander, James, Compton-house, Hounslow.
Mulhall, Michael G., 19, Albion-st., Hyde-park, W.
Myer, Horatio, 5, Randolph-gardens, N.W.
O'Neill, Edward Henry, Knowsley-house, Highbury New-park, N.
Palmer, George, 58, Ebury-street, S.W.
Pearce, Staff-Commander William, R.N., Admiralty, S.W., and 2, Orlando-road, Clapham, S.W.
Perry, Archibald Hewison, 6, Friends-road east, Croydon.
Sheath, George F., Eastrop-villa, 22, Quadrant-road, Canonbury, N.
Simpson, Reginald Wynne, 14, Cornwall-gardens, South Kensington, S.W.
Thornton, Henry, 42, Burlington-road, Westbourne-park, W.
Thresh, John Clough, D.Sc., F.C.S., Buxton.
Usill, George William, Haldon-lodge, Wandsworth, S.W.
Wells, William, Markenfield, Guildford, Surrey.
Wright, William, Moor-house, Kew-bridge, Brentford.

The CHAIRMAN nominated Dr. Mann and Mr. Barker, scrutineers, and declared the ballot open.

The SECRETARY then read the following—

REPORT OF THE COUNCIL.

I.—ORDINARY MEETINGS.

The first meeting of this, the 131st Session of the Society, was held on the 29th of November last, when Sir Frederick Abel, the Chairman of the Council, delivered, in accordance with the usual custom, the Opening Address of the Session. In it Sir Frederick dealt with some of the most recent applications of science, and touched on many topics which, later in the session, formed the subject of papers read before the Society. Amongst the chief matters treated may be mentioned the practical applications of electricity; the condensation of gases, and the application of such condensed gases to various industrial purposes; the use of liquid fuel; the analysis of food; technical education; and the Health Exhibition, then just closed.

This last-named subject was taken up and treated at greater length in a paper read at the second meeting of the Session by Mr. Ernest Hart, who, like Sir Frederick Abel, had been one of the Council of the Health Exhibition. At the reading of this paper the Duke of Buckingham, the Chairman of the Exhibition, presided. On the succeeding Wednesday Mr. W. H. Preece, who, like many other members of the Society, had taken part in the visit of the British Association to Canada last autumn, gave the result of his observations on the subject of "Electric Lighting in America." At the following meeting another of the topics which had been touched on by the Chairman was treated at greater length by Mr. Jurgens, whose paper on the "Preparation of Butterine" will, it may be hoped, have served to give the public some accurate ideas as to the manufacture of this now common and wholesome article of food, and may have done something to remove part at least of the prejudices against it. At the last meeting before Christmas, Mr. Simmonds, to whom for many years past the Society has been indebted for valuable statistical communications, read a paper upon "The Timber Supplies of Great Britain."

At the first meeting after Christmas, Mr. Tweddell, whose inventions have been of so much practical service in extending the use of hydraulic machinery for various purposes, gave an account of the development of this branch of engineering. Other papers dealing with various mechanical matters were those by Mr. Scott-Moncrieff on "Methods of Supplying Steam Boilers;" by Professor Shaw, on "The Evolution of Machines;" and by Mr. Mayall, on "Nobert's Ruling Machine."

Papers dealing with educational matters were those by Mr. C. Leland, who, under the title of "Education in Industrial Art," gave an account of the recent attempts in the United States to instruct children of elementary schools in applied Art; and that of Mr. Henry Cunynghame, Assistant Charity Commissioner, who treated the subject of Technical Education from a somewhat novel point of view. Another paper dealing with an important educational subject was that of Mr. Brudenell Carter on the "Influence of Civilisation upon Eyesight."

Papers which may be classed together as treating various sanitary subjects were those on the "Report of the Royal Commission on Metropolitan Sewage," by Captain Douglas Galton; two papers, read on the same evening, by Dr. Richardson and Dr. Hawksley, the former on "The Removal of House Refuse," and the latter on "An Improved System of Dry Closets;" and a paper on the "Rivers Pollution Bill," by Mr. Willis Bund.

Mr. Pidgeon's paper on "Labour and Wages in the United States," had the advantage of the presence in the chair of Mr. Russell Lowell, the late American Minister. Mr. A. J. Ellis added one more to the number of the valuable classical papers on musical science which he has given to the Society, by reading a paper on the "Musical Scales of Various Nations." Prof. Ray Lankester's paper, advocating the establishment of a Marine Laboratory, had the happy result of inducing the Fishmongers' Company to take the matter up, and to contribute liberally to the funds required for the establishment of the proposed institution. General Feilding's paper on an "Outfit for Explorers," gave the result of his experience in such matters, and dealt in an interesting manner with the equipment necessary for at least one system of exploration. Mr. Wardle, in his "Researches on Silk Fibre," gave the result of a long series of experiments he has been conducting on the subject; and Mr. Stopes dealt with the present condition of another important industry in his paper on "Malt-making." The last paper of the Session was read by Professor Dewar, the subject being "The American Oil and Gas Fields," which the author had visited last autumn. Professor Dewar's paper had the advantage of being extensively illustrated, a specially interesting experiment, the liquefaction of marsh-gas, being shown for the first time in public.

II.—Indian Section.

The Indian Section this Session was remarkable for the fact that there were no fewer than eight meetings. Two of these were extra meetings, one of them, and the most important of the whole Section, being summoned to hear Professor Arminius Vambéry's lecture on "Herat." All the other papers were of a high degree of interest, and more than one helped materially to increase the amount of easily accessible information available on the subject of which it treated.

The first paper was contributed by Mr. E. C. Buck, Secretary to the Government of India in the Revenue and Agriculture Department, and the subject, of which, to use the words of Sir James Caird, the chairman on the occasion, the author showed a "thorough grasp," was the suggestive one of "The Agricultural Resources of India." The conclusion to which Mr. Buck came was that while much remained to be done, "the condition of the cultivators is materially better than it was fifty years ago." The second paper was on the "Teak Forests of India and the East, and our British Imports of Teak," in which the author, Mr. P. L. Simmonds, gave a very complete account of our present and prospective stores of this wood valuable for shipbuilding, for railway carriage building, and for many other purposes. In the third paper, Mr. Frederic Holmwood, British Consul at Zanzibar, supplied a detailed description of "Trade between India and the East Coast of Africa." The object of this paper was to show the necessity of prompt measures being taken to ensure the internal development of the Sultan of Zanzibar's dominions, and to preserve the commercial pre-eminence which English subjects have long enjoyed there. The fourth paper was by a Parsee gentleman of Bombay, Mr. Mancherjee M. Bhownaggree, on the "Present Condition and Future Prospects of Female Education in India," in which a variety of suggestive facts bearing upon the subject were brought together, and placed in a clear and attractive way before an English audience. In the fifth paper, by Mr. Jehangeer Dosabhoy Framjee, another Parsee gentleman in the service of the Bombay Government, gave a well-written account of "The Parsis and the Trade of Western India," showing the connection between the two, and the share which his community had possessed, and still possesses, in the commerce of Bombay. The sixth evening was devoted to Prof. Vambéry's lecture on "Herat," already referred to, when, on account of the large demand for admission, the lecture had to be given in Exeter-hall. The seventh paper was Dr. Pringle's "Ancient and Modern Methods of Treating Small-pox Epidemics in India," in which the writer gave some highly interesting particulars, collected during his long experience as a member of the Sanitary Department in India, of the practice of inoculation. The eighth and last paper of this Section was a solid contribution to our geographical and general knowledge of the Shan States, provided by Professor R. K. Douglas, under the attractive title of "The Golden Road to South-West China." The results of the Session

were distinctly encouraging both as regards the quality of the papers and the interest taken in the knowledge thus diffused on questions connected with India.

III.—Foreign and Colonial Section.

In the Foreign and Colonial Section, Mr. Stephen Bourne opened the Session with an account of the visit of the British Association for the Advancement of Science to the north-western districts of Canada, in 1884, following the course traversed by the Canadian Pacific Railway to its most advanced station in the Rocky Mountains, lying within 250 miles of the Pacific coast. Mr. William Sowerby gave a detailed description of the auriferous region of Spain, which extends along the Valley of the Rio Sil, from the southern slopes of the Western Pyrenees to the northern frontier of Portugal, comprising some 5,000 square miles, and including the site of the mines from which the ancient Romans procured very much of their gold, and which still yield, under very unfavourable conditions of working, an average of about 15 grains of gold per ton. Commander Cameron reported on the arrangements and prospects of the Free State of the Congo, with some critical remarks concerning the spirit and labours of the International Association, and of the Berlin Conference. Mr. H. H. Johnston contributed a very interesting paper on the Kilima-njaro region of Equatorial Africa, giving a narrative of his recent sojourn of some months on the slopes, and at the base, of the great Snow Mountain, and insisting upon the value and salubrity of the district as a site for future industrial occupation and work. Mr. John Eldon Gorst communicated his views of the steps which he thought practicable for forwarding the Federation of the Colonial Dependencies with Great Britain for purposes of mutual assistance and defence. At the last meeting of the Section, Mr. Wilfred Powell gave an account of the inhabitants of New Britain, the Duke of York's Islands, and New Ireland, lying immediately to the east of New Guinea, and described them as a people possessing marked docility, and some skill in the ruder arts of life, although still debased by inveterate habits of cannibalism.

IV.—Section of Applied Chemistry and Physics.

In the Section of Applied Chemistry and Physics five papers were read. The first of these was by Mr. Frederick Siemens, who gave the Society an account of the process he has perfected for the production of hardened—or, as he prefers to call it, "tempered"—glass. The glass is not treated, as in De la Bastie's process, in a bath of oil; but the effect is produced by pressure between cold surfaces, or by cooling down the glass in air. In the second paper of the Session Mr. Beilby described the methods devised by Mr. Young and himself for the manufacture of ammonia from coal and shale, and described the results which had already been attained by them in the direction of manufacturing from coke a gas suitable for heating purposes, and also sulphate of ammonia. This paper was followed by one by Mr. Burton on "Recent Improvements in Photographic Development," in which an account was given of a series of experiments which the writer recently carried out with the view of ascertaining the comparative value of the various agents which have of late been introduced for the purpose of developing the photographic image. The "Chemistry of Ensilage" formed the subject of a paper by Mr. Lloyd, who has been following up the work of the late Dr. Voelcker in this direction. The work of the Section was brought to an end by Dr. Thresh, who has lately made some interesting and successful attempts to purify the sewage of Buxton, in Derbyshire, by the use of the natural chalybeate waters of the district, mixed with lime.

V.—Cantor Lectures.

During the past Session there have been seven courses of Cantor Lectures. Three of these may be considered as dealing with branches of applied chemistry: the first course, on "Coal Gas," by Mr. Dixon; the fourth, on the "Chemistry of Pigments," by Mr. J. M. Thomson; and the seventh, on the "Manufacture of Soap," by Dr. Alder Wright. The "Distribution of Electricity," formed the subject of the third course, by Professor Forbes. In the sixth course Captain Abney gave the results of his most recent photographic researches, under the title of "Photography and the Spectroscope." An artistic subject was treated in the fifth course, by Mr. Hungerford Pollen, on "Carving and Furniture;" and in the second course, Dr. G. V. Poore lectured on "Climate and its Relation to Health."

VI.—Howard Lectures.

The Council were able to announce in last year's report that they had been fortunate enough to secure the assistance of Mr. William

Anderson for a course of six lectures, to be delivered under the Howard Trust. The anticipations then expressed by the Council were fully justified, for perhaps no more interesting or valuable course of lectures has ever been delivered before the Society than that which Mr. Anderson gave on "The Conversion of Heat into Useful Work." These lectures, which have already appeared in the *Journal*, will be shortly republished by Mr. Anderson, with some slight additions.

VII.—Juvenile Lectures.

As usual, a short course of Juvenile Lectures was given during the Christmas holidays to the children of members. The lecturer was Professor Norman Lockyer, who took for his subject "Universal Time: our future Clocks and Watches." The lectures gave in a popular form the results of the Prime Meridian Conference held last year at Washington, and explained the advantages which might be expected to result from the adoption of the system of numbering the hours continuously from one to twenty-four.

VIII.—Additional Lecture.

In December last a lecture was given by Dr. Richardson, on "The Painless Extinction of Life in the Lower Animals." In it Dr. Richardson described the plans he had elaborated, after considerable experiment, for the suffocation of dogs by means of a mixture of carbonic oxide and chloroform vapour. The application of the system to the slaughter of animals for food purposes was referred to; but the lecturer held out small hope of any practical result from his experiments in this direction at present.

IX.—Medals.

The Council have awarded nine Silver Medals to the authors of papers read during the past Session. Of these, four have been for papers read at the Ordinary Meetings, two for papers read in the Indian Section, one for a paper read in the Foreign and Colonial Section, and two for papers read in the Section of Applied Chemistry and Physics. The Council have always considered it undesirable that they should award medals to any members of their own body, and amongst the papers read during the past Session there were no less than five, the importance of which they were, therefore, precluded from recognising otherwise than by a vote of thanks. The papers in this category were by—

W. H. Preece, F.R.S., on "Electric Lighting in America."

R. Brudenell Carter, F.R.C.S., on "The Influence of Civilisation upon Eyesight."

Capt. Douglas Galton, C.B., F.R.S., on "Report of the Royal Commission on Metropolitan Sewage."

B. W. Richardson, M.D., F.R.S., on "Removal of House Refuse independent of Sewage."

Prof. James Dewar, F.R.S., on "The American Oil and Gas Fields."

The following is a complete list of the awards of the medals:—

To Anton Jurgens, for his paper on "The Preparation of Butterine."

To P. L. Simmonds, for his paper on "Present and Prospective Sources of the Timber Supplies of Great Britain."

To A. J. Ellis, B.A., F.R.S., for his paper on "The Musical Scales of Various Nations."

To Thomas Wardle, for his paper on "Researches on Silk Fibre."

To H. H. Johnston, for his paper on "British Interests in East Africa, especially in the Kilimanjaro District."

To E. C. Buck, for his paper on "The Agricultural Resources of India."

To Mancherjee M. Bhownaggree, for his paper on "The Present Condition and Future Prospects of Female Education in India."

To Dr. Frederick Siemens, for his paper on "Tempered Glass."

To Frederick J. Lloyd, for his paper on "The Chemistry of Ensilage."

X.—Albert Medal.

The Albert Medal for the present year has been awarded to Mr. Henry Doulton, "in recognition of the impulse given by him to the production of artistic pottery in this country."

It was about 1871 that the firm of which Mr. Henry Doulton is the head—a firm which had long been noted for the manufacture of drain-pipes, sanitary and chemical appliances, and other earthenware—undertook the production of artistic pottery; though as far back as 1855 the manufacture of terra-cotta had been commenced at the Lambeth potteries. In 1871, Messrs. Henry Doulton and Co. showed a magnificent collection of the ware which has since gained the distinctive name of "Doulton Ware" at the Exhibition held at South Kensington. The results, however, then shown were hardly more than of an experimental character. Two years later, at the Vienna Exhibition of 1873, a much finer series of artistic stoneware was shown by Messrs. Doulton. Consequent on this Exhi-

bition, the demand for the Doulton ware largely increased, and in 1880, the manufacture of the under-glazed painted earthenware, which is distinctively known as Lambeth Faïence, was separated from the Doulton Ware Department and accommodated in new studios by itself. Still the manufacture grew, until in 1882 it was found necessary to construct an entirely new building for the accommodation of the two Art Departments.

The Council have felt that the establishment of a new industry of this character fully justified the award of the Albert Medal, but while recording this fact they wish it to be understood that in making the award they had also in view the other services rendered by Mr. Doulton to the cause of technical education, especially the technical education of women, to sanitary science by the productions of his firm, and, though in a less degree, to other branches of science, by the manufacture of appliances of suitable character.

XI.—International Inventions Exhibition.

The connection between the Society, and the series of annual International Exhibitions at South Kensington, which commenced with the Health Exhibition, was continued in the case of the Exhibition now in progress, which deals, in its first Division with Inventions, and in its second with Music. The meetings of the Executive Council, appointed by the Prince of Wales, commenced in the Society's Rooms in June last year, and were continued till the opening of the Exhibition last month, since which time it has been found more convenient that they should be held in the buildings of the Exhibition itself. The Society also provided accommodation for the various committees of selection, whose work was carried on from November till February, and to whom were submitted all the applications for space. The assistance thus afforded is believed to have been of considerable service to the Exhibition, and to have greatly facilitated the arrangements necessary for the proper carrying out of so extensive a scheme. The Council also readily acceded to a suggestion of the Executive of the Exhibition that the Society's *Journal* should be made the official organ of the Exhibition. As an acknowledgment of the help afforded in this and other ways, the Executive granted to members of the Society the privilege of purchasing season tickets at a reduced rate, a privilege of which over 700 members have availed themselves. This number is in excess of the corresponding number last year, when just 400 tickets for the Health Exhibition were sold under similar conditions. The Executive have also, as stated in another part of this report, placed the Exhibition buildings at the disposal of the Society for the holding of the annual Conversazione, a privilege of considerable value, when it is remembered how great a difference is made in the day's receipts by the fact of the buildings being closed for the evening.

XII.—Inventions Exhibition Prizes.

The success which attended the offer of special prizes by the Society, in connection with last year's Exhibition, and the high estimation in which those prizes appeared to be held by the recipients, together with the fact that the Council had at their disposal certafn funds, the income of which was available for such purposes, induced them to make a similar offer to the exhibitors in the Inventions Exhibition. The trust funds which could be applied for prizes such as might fairly be offered in connection with this Exhibition were the "John Stock," the "Howard," and the "Fothergill."

As the John Stock Prize was specially in tended for the promotion of some branch of the fine arts, it was thought well to offer it for an invention in a department of science which has done a great deal of late years for the popularisation of Art, by the reproduction of engravings, etchings, and other pictures in black and white, by mechanical processes, based upon photography; and, accordingly, a Gold Medal was offered for "The best application of Photography to a Permanent Printing Process."

The Howard Trust was left to provide a prize either for a treatise on motive power, or for an invention connected therewith. As a portion of the accumulated funds under this trust have lately been devoted to the providing of a course of lectures on this subject, which will shortly appear in book form as a treatise, it was evident that no better destination could be wished for the balance than to expend it in prizes for inventions shown in the present Exhibition, and coming within the limits assigned by the testator. Accordingly, five Gold Medals were offered under this trust, for prime movers of various classes.

Under the Fothergill Trust, in which the freedom of choice of the Trustees is less restricted than in many of the other funds left

in charge of the Society, a Gold Medal was assigned for the best exhibit in the class devoted to "Philosophical Instruments and Apparatus."

Finally, as it seemed proper that the offer of the Society's prizes should not be confined to the First Division only of the Exhibition, three Gold Medals were offered for the Second Division of the Exhibition. The amount required for these medals will come out of the funds left in 1870 by Mr. Alfred Davis to the free disposal of the Council.*

XIII—.International Health Exhibition Prizes.

The prizes which were offered in connection with the International Health Exhibition, out of the trust funds of the Society, were all duly awarded. Full particulars of these awards have already appeared in the *Journal*.†

XIV.—Westgarth Prize Essays.

It was stated in last year's report that, by the liberality of Mr. William Westgarth, a member of the Society, the Council had had a sum of £1,200 placed at their disposal, to be awarded in prizes for essays on "Dwellings for the Poor," and on the "Reconstruction of Central London."

This amount, in accordance with Mr. Westgarth's wishes, was divided into five prizes:—

A prize of £250, for an essay upon the rehousing of the poorer classes of the metropolis.

A prize of £500, for an essay upon the sanitation, street re-alignment, and reconstruction of the central part of London.

Three prizes of £150 each, for essays dealing with (1) the engineering considerations; (2) the architectural considerations; (3) the sanitary considerations.

The date for the reception of the essays was the 31st December last. By that date twenty-seven essays had been sent in, and these were referred for consideration to a committee appointed by the Council.

This Committee reported to the effect that in their opinion none of the essays realised the requirements of the offer in such a manner as to justify them in recommending that the full amount of the prizes offered by Mr. Westgarth should be awarded. They recommended, however, that there should be awarded prizes amounting in all to £600, viz.:—Three prizes of £100 each; three prizes of £50 each; and six prizes of £25 each. A list of the successful candidates has been given in the *Journal*.*

The Council, after consultation with Mr. Westgarth, accepted the report of the Committee and awarded the prizes as recommended. It was also determined that the three Essays to which prizes of £100 were awarded shall be published on behalf of the Society, and these are now in the hands of the printer.

XV.—Owen Jones Prizes.

These prizes, which have been awarded annually since their institution in 1878, are provided by the interest on the sum of £400, presented to the Society of Arts by the Owen Jones Memorial Committee, this amount being the balance of the subscriptions collected by that committee. They are awarded on the results of the annual competition of the Science and Art Department to students of the Schools of Art, who produce the best designs for household furniture, &c., on the principles laid down by Owen Jones. Six prizes were offered for competition last year, each prize consisting of a bound copy of Owen Jones's "Principles of Design" and a Bronze Medal. A list of the successful candidates has appeared in the *Journal*.† A similar number of prizes has been offered for the present year (1884-5.)

XVI.—Conference on Water Supply.

The Conference on Water Supply, the announcement of which was made in the last report of the Council, was held at the International Health Exhibition on the 24th and 25th of July, 1884. This Conference, as will be remembered, was held by the Society as one of the series of Conferences on subjects connected with Health which the Exhibition authorities had invited some of the principal London societies to organise. When the arrangements were first made, H.R.H. the President of the Society, had graciously consented to take the chair; but the sudden death of H.R.H. the Duke of Albany prevented his keeping this engagement, and the holding of the Conference was deferred to a later date than that which was originally fixed. In the result, a valuable series of papers was contributed by many well-known writers, the papers and discussions being arranged under the following heads:—(1) Sources of Supply; (2) Quality of Water;

* For fuller details of the terms of the offer of these prizes, see *Journal*. January 9, 1885.

† See *Journal* of Oct. 31, 1884, p. 1109; also *Journal* for Dec. 12, 1884, p. 81.

* See *Journal*, June 5, 1885, p. 803.

† See *Journal*, August 22nd, 1884, p. 941.

Filtration and Softening; (3) Methods of Distribution; Modes of giving pressure; House Fittings, &c. The proceedings were presided over by Sir Frederick Abel, the Chairman of the Council, who opened the Conference with a short address. A full report of the papers, and of the discussions upon them appeared in the *Journal* of the 25th of July, 1884, and succeeding numbers.

XVII.—Conference on Patent-law.

The holding of the Inventions Exhibition appeared to offer a suitable opportunity for holding a Conference on Patent-law, especially on International Patent-law, and after considering the question, the Council determined to issue invitations for such a Conference. Upon further consideration, however, it appeared better that an application should be made to the authorities of the International Convention for the Protection of Industrial Property, who had already announced the holding of a Conference on International Patent-law in Rome during the present year, inviting them to hold their Conference here in London. The officials of the Board of Trade and of the Foreign-office were good enough to take much interest in the matter, and through their assistance, proper application was made to the Italian Government, and to the International Convention, suggesting that the locality of the Conference should be changed. Eventually, however, it appeared that the Italian Government were desirous of postponing the Conference for a year, and that the members of the International Convention also thought that, having regard to the shortness of time which had elapsed since the establishment of the Convention, it would be undesirable to discuss questions of International Patent-law during the present year. Under these circumstances, and considering also the fact that the English Patent Act has not yet been in operation for two years, the Council came to the conclusion that the time was hardly ripe for discussion of the questions which would naturally come before the Conference, and they, therefore, abandoned the intention of endeavouring to hold it.

XVIII.—Examinations.

This year shows a steady increase in the number of candidates, 1,208 having presented themselves at 44 centres; whereas last year there were 991 candidates, and 38 centres. Of these 1,208 candidates, 953 passed, and 255 failed. The number of papers worked was 1,321; of these, 145 took first-class certificates, 410 second-clsss, and 474 third-class, while to 292 papers no certificate was awarded. Eleven of the 13 subjects set down for examination were taken up. In two (Italian and Commercial Geography), no examination was held, as the requisite number of candidates (25) did not present themselves. The largest number of papers worked (336) was in Book-keeping. Other favourite subjects were:—Arithmetic, 171; English (including composition and correspondence and précis writing), 118; Shorthand, 253; Theory of Music, 243. In French there were 96 candidates; in German, only 28.

That more candidates should not present themselves for examination in modern languages is still a source of regret. It was only by special effort that the minimum number of entries was collected for the examinations in German and in Spanish, while in Italian there were hardly any entries at all.

Only one change of any importance is proposed for the programme of next year, the omission of the subject of Sanitary Knowledge, in consequence of the Science and Art Department now holding an examination in "Hygiene." Notice was given last year that this examination would be discontinued after the present year.

XIX.—Practical Music Examinations.

As in previous years, practical examinations in Music have been held at London, Liverpool, and Glasgow. At London there were 181 candidates, of whom 160 passed, taking 61 first class, and 123 second class certificates, with two first and three second class honours. At Liverpool 42 candidates presented themselves, all of whom passed; 17 first class certificates were awarded, and 32 second. At Glasgow 72 candidates entered, 66 of whom passed, taking 25 first class, and 41 second, with two first and one second class honours. It will be understood that many of the candidates were examined both in the pianoforte and singing, and consequently the number of the certificates awarded does not agree with the total number of candidates passing. On a comparison with previous years being instituted it appears that the standard of excellence is well kept up, though the numbers of candidates do not show that increase which might fairly be anticipated, considering the moderate amount of the fees, and the proved value of the certificate, especially to teachers.

XX.—Optical Glass.

The suggestion made by Professor Norman Lockyer, in his lectures last session on optical instruments, that the Society should make some inquiries into the manufacture of optical glass in this country, with a view, if possible, of improving the condition of that manufacture, was taken up by the Council, and a committee, with Mr. Lockyer as chairman, was appointed to consider and report on the subject. The first point the committee set themselves to ascertain was, was whether large discs for refracting telescopes could not be obtained by some method less costly than the process of casting followed by a lengthened period of annealing. The committee had under consideration several propositions put forward with the above object, and they are much indebted to Messrs. Chance and Messrs. Powell, the well-known firms of glass-makers, for most liberally undertaking at their own cost, some experiments proposed with the view of finding out what chance there was of these suggestions being successfully carried out in practice. The results of these experiments the Committee hope soon to be able to report upon.

XXI.—Corporate Property Bill.

The attention of the Council was drawn to the provisions of the Corporate Property Security Bill, introduced this Session in the House of Commons by Sir Charles Dilke and the Attorney-General (Sir H. James.) It seemed evident that some of the provisions of the Bill would injuriously affect the Society of Arts, and might seriously hamper the Society in regard to the disposal of its own property; the Council, therefore, resolved that a petition, drawing attention to the effect which the Bill would have on chartered Societies such as the Society of Arts, should be drafted and presented to the House of Commons. Such a petition was accordingly prepared, and Mr. Edward Birkbeck, M.P., a member of the Council, was good enough to present it on behalf of the Society.*

XXII.—Conversazione.

The success which attended the Conversazione given jointly last year by the Society of Arts and the Executive Council of the Health Exhibition, as well as that given the preceding year at the Fisheries Exhibition by Sir William Siemens, led the Council to apply to the authorities of the Inventions Exhibition for permission to hold the Conversazione for the present year in the Exhibition Buildings. It appeared that the Executive had no intention of themselves holding a Conversazione, but they expressed their willingness to place the buildings at the disposal of the Society, provided only they could be secured against actual pecuniary loss. As the large outlay necessary for holding a Conversazione on a similar scale to those of last year and the year preceding, could not legitimately be met from the resources of the Society, it became evident that some arrangement must be adopted for providing the necessary funds. For this purpose, no plan seems better than that which has been successfully employed by the Royal Botanic Society for their evening fêtes; that is to say, permitting members of the Society to purchase additional tickets for the use of their friends, while, at the same time, carefully restricting the sale of such tickets. Arrangements to this effect were accordingly made, and an announcement of the terms on which tickets could be procured was given in the *Journal*.* The Council have learned with satisfaction that the course they have pursued has been approved by the members, and are glad to be able to announce that a sufficient number of tickets have been sold to provide a fund which, when added to the amount which can with propriety be expended for such a purpose from the Society's revenue, will amply suffice to defray the cost. The members should understand that the admissions will be restricted to members of the Society, holders of tickets purchased by members, and persons specially invited on behalf of the Society in accordance with the usual practice. It is understood that the Executive Council of the Exhibition are not likely again to exercise the right they have reserved to themselves of closing the Exhibition to the public on certain evenings. Should this be so, they will only have availed themselves of two out of the four evenings (two Wednesdays and two Fridays) they reserved for special fêtes.

The Council feel that the members of the Society are greatly indebted to the Exhibition authorities for so liberally acknowledging the services which the Society has been able to render the Exhibition.

XXIII.—Electric Lighting of the Society's House.

During the past year the installation of electric light on the Society's premises has

* See *Journal*, April 3rd, 1885, p. 553.

* See *Journal* of May 15th and following numbers.

been completed by the purchase of a secondary battery, which has been supplied by the Electrical Power Storage Company. This battery serves as a regulator to the current employed in lighting the Great Room, and since it has been in use the lamps have worked with perfect steadiness. It also enables the Council-room, and the other offices of the Society, to be lighted by electricity without the necessity for running the gas-engine and dynamo.

XXIV.—Ten-Volume Index to Journal.

In November last, an index to the ten volumes of the *Journal* of the Society of Arts—vols. 21 to 30, 1872 to 1882—was issued and distributed to those members who made application for it. General indexes had also been published to the first ten volumes of the *Journal*, and to the second ten volumes—11 to 20. A reference to the whole series of the *Journal*, from 1852 to 1882, can, therefore, now be made by means of these three indexes. As regards the two volumes which have been completed since November, 1882, reference must still be made to the annual indexes which are published at the conclusion of each volume.

XXV.—List of Members.

The increase in the number of members still continues, the number of new elections being larger, and the number of retiring members being smaller than either last year or the year before. The total number of life members, subscribing members, and institutions in union which subscribe to the Society from their own funds, is now 3,656, or 105 more than at the corresponding period last year, when the number was 3,551. During the year 1884-5, 270 members have been removed from the list by death or resignation. During the same period, 375 have been elected.

XXVI.—New Council.

A balloting list for the election of the new Council is submitted in the usual form to the members. H.R.H. the President has been pleased to nominate, as a Vice-President, his son, H.R.H. Prince Albert Victor, in addition to H.R.H. the Duke of Edinburgh, who has been for several years a Vice-President of this Society, and the Council are sure the members will fully appreciate the fresh proof of interest in the Society thus shown by the Prince of Wales. Amongst those proposed for election as Vice-Presidents are three gentlemen who have served during the past year as ordinary members of Council :—Sir Frederick Abel, Mr. Birkbeck, and Professor Dewar. Mr. Owen Roberts's term of office as Treasurer having expired, the Council propose him for election as a Vice-President, Mr. Francis Cobb taking his place as Treasurer on the ballot list. In addition to these are three entirely new members :—The Duke of Buckingham and Chandos, Sir Frederick Leighton, and General Sir Henry Ponsonby. As new members of Council there are proposed Mr. Vicat Cole, R.A., Mr. William Anderson, Col. Hamilton, and Mr. Charles Cheston, in place of the four retiring in accordance with the bye-laws.

XXVII.—Obituary.

Among the losses which the Society has sustained by the death of some of its distinguished members may be mentioned those of Sir Erasmus Wilson and Sir Charles Freake (both of whom had in the past years served on the Society's Council); Mr. Charles Manby, for long the well-known Honorary Secretary of the Institution of Civil Engineers; Dr. Voelcker, the distinguished chemist; Mr. Sidney Gilchrist Thomas, one of the inventors of the basic process for the production of steel; Mr. William Hawes, for many years a member of Council, and twice its chairman; Sir Thomas Bazley, who, some years back, held the office of Vice-President, and most recent of all, the distinguished electrician Professor Fleeming Jenkin. Brief notices of these, and of other deceased members of the Society, have already appeared in the columns of the *Journal.*

XXVIII.—Finance.

In accordance with the provision to that effect in the Bye-laws, the Treasurers' Statement of Receipts, Payments, and Expenditure for the year ending May 31st last has already appeared in the Society's *Journal*. A careful examination of this statement will show that the finances are in a thoroughly sound state, and that the prosperity of the Society continues to increase. It does not appear that there are many items in the Financial Statement which differ very greatly from the similar heads in the statements of recent years, or on which, therefore, any explanation is required. It may be noted that the subscriptions have reached the high amount of £6,999, which appears to be the largest sum ever received in any year by the Society. This increase is in the annual subscriptions, the amount of life compositions paid during the year being somewhat below the average of recent years. As regards the

statement of assets and liabilities, it may be noted that, while the liabilities of the Society do not differ very greatly from the same item last year (being £2,321 as against £2,482), the excess of assets over liabilities shows a satisfactory increase of £1,500, since it amounts to £11,581 as compared with £10,099 last year.

The CHAIRMAN, in moving the adoption of the Council's report, congratulated the Society upon the importance and usefulness of its work during the past Session. Many interesting subjects had been discussed at the ordinary and sectional meetings, more especially in those of the Indian Section. In noticing the various courses of lectures given during the Session, he particularly alluded to the valuable course on "The Conversion of Heat into Useful Work," delivered by Mr. Anderson under the terms of the Howard Trust.

Lord ALFRED CHURCHILL, in seconding the motion, referred to the system of examinations, and to the encouraging increase in the number of candidates—a system which exerted a wide influence over the country, and was carried on by the Society at comparatively small cost.

Mr. W. LASCELLES-SCOTT asked a question with regard to the disposal of the accumulation of interest from the Trust Funds held by the Society.

Commissary-General DOWNES, C.B., and Mr. BARKER both referred to the privilege accorded to members of the Society by the Executive of the Inventions Exhibition of purchasing season tickets at half-price, which was much appreciated, but they wished that the privilege had been extended so as to allow members to purchase a second ticket on the same terms for a lady.

Mr. J. H. BLAKESLEY commented upon the arrangements by which tickets for the Society's Conversazione were sold, and asked whether the Society was in any way responsible for the management of the Inventions Exhibition.

Mr. CARL THIMM pointed out that the report contained no reference to the library, which ought to be an important department of the Society.

Mr. MARTIN WOOD referred to the great advantages offered by the examinations, and mentioned that he himself had been much indebted to them in past years. He also alluded to Mr. Hyde Clarke's proposal for forming an institute of living languages, and strongly advocated its establishment.

Sir FREDERICK ABEL replied to the various points raised by the several members, and pointed out that with a proper consideration to the guarantors, the Executive Council of the Exhibition were unable to enlarge the considerable privilege which had been extended to the members of the Society. The Council had gladly accorded to the Council of the Exhibition such assistance as was in their power, but the Society of Arts was in no way connected with the management of the Exhibition. He thought the Society would be satisfied with the arrangements by which extra tickets for the Conversazione were sold to members, as otherwise it would have been impossible to hold the reception at the Exhibition.

The report was then adopted.

The ballot having remained open for one hour, and the scrutineers having reported, the CHAIRMAN declared that the following had been elected to fill the several offices. The names in *italics* are those of members who have not, during the past year, filled the office to which they have been elected.

PRESIDENT.

H.R.H. the Prince of Wales, K.G.

VICE-PRESIDENTS.

H.R.H. the Duke of Edinburgh, K.G.
H.R.H. Prince Albert Victor of Wales, K.G.
Sir Frederick Abel, C.B., D.C.L., F.R.S.
Sir George Birdwood, M.D., C.S.I.
Edward Birkbeck, M.P.
Sir Frederick Bramwell, F.R.S.
Duke of Buckingham and Chandos, G.C.S.I.
Andrew Cassels.
Edwin Chadwick, C.B.
Lord Alfred S. Churchill.
Sir Philip Cunliffe-Owen, K.C.M.G., C.B., C.I.E.
Prof. James Dewar, M.A., F.R.S.
Captain Douglas Galton, C.B., D.C.L., F.R.S.
Earl Granville, K.G., F.R.S.
Marquis of Hamilton, C.B.
Sir Frederick Leighton, P.R.A.
George Matthey, F.R.S.
General Sir Henry F. Ponsonby, K.C.B.
W. H. Preece, F.R.S.
Sir Robert Rawlinson, C.B.
Owen Roberts, M.A., F.S.A.
Lord Sudeley.

ORDINARY MEMBERS OF COUNCIL.

W. Anderson.
Sir Francis Dillon Bell, K.C.M.G.
Alfred Carpmael.
R. Brudenell Carter, F.R.C.S.
Charles Cheston.
Vicat Cole, R.A.
Thomas Russell Crampton.
Colonel A. Hamilton, R.E.
Thomas Villiers Lister.
J. M. Maclean.
W. G. Pedder.
R. E. Webster, Q.C.

TREASURERS.

B. Francis Cobb. | W. R. Malcolm.

SECREARY.

H. Trueman Wood, M.A.

The usual vote of thanks to the Scrutineers, moved by the CHAIRMAN, was carried unanimously.

Sir F. DILLON BELL proposed a vote of thanks to the Chairman, which was seconded by Mr. BARKER, and carried unanimously.

Sir FREDERICK ABEL, in replying, referred to the assistance of his colleagues on the Council, and of the Secretary, and concluded by proposing a vote of thanks to the officers of the Society, which was seconded by Mr. LASCELLES-SCOTT, and carried unanimously; and was acknowledged by the Secretary.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The number of visitors to the Exhibition for the week ending Tuesday, 23th inst., was 153,180. Total since the opening, 985,623.

MUSICAL PITCH.

A public meeting, convened by the Royal Academy of Music, and presided over by its principal, Professor Sir GEORGE MACFARREN, was held on Saturday, 20th inst., at St. James's-hall, "to consider the desirability of a standard musical pitch for the United Kingdom."

The CHAIRMAN, in opening the proceedings, observed that the variation of the pitch used in this country and abroad caused very great inconvenience to persons who practised the art of music interchangeably in different nations. The subject had received serious attention a quarter of a century ago from the Society of Arts, when much practical experience was recounted, but the result had been *nil*. The matter had again made demands on public attention, and the direct occasion of their being invited to that meeting was an official communication from the Foreign-office to the directors of the Royal Academy of Music.

Mr. SANTLEY, in moving the first resolution, "That it is desirable to fix a standard for musical pitch throughout the United Kingdom which may accord with that of other countries," said he thought it was quite necessary that there should be a uniform pitch throughout the musical world. All instrumentalists agreed that this should be so for their instruments, and therefore it should be so for the most delicate instrument of all—the human voice. When one was accustomed to sing in one pitch it was next to impossible to sing in tune on going immediately to another pitch.

Mr. ALEXANDER ELLIS, F.R.S., seconded the resolution, and said it would seem to be almost a self-evident proposition that the pitch used in music should be uniform, in order that singers might be aware of the pitch to which they could go, and composers might be aware of the pitch they could demand from singers. The facts, however, served to show that this never had been evident. About 300 years ago, when the playing of instruments together was not particularly common, they were informed by Pretorius that instruments were tuned according to the fancy of the maker as to what would add brilliancy or sonority to them. Pretorius was not satisfied, and worked out what he considered a suitable pitch. That pitch was, for A, 424. When the Philharmonic Society was established in 1813 they selected 423½. For nearly 200 years, in fact, they were in possession of a tolerably uniform pitch, but the year 1814 saw a change. That was the year of the Congress of Vienna, where several crowned heads assembled, amongst others, the Emperor of Russia, who presented a new brass band to one of the three household regiments of Vienna. That set of instruments was very much sharper than any other instruments previously made; but one of the Grand Dukes of Austria, not to be outdone, presented another set of instruments to another household regiment of Vienna, and this set was still sharper. The two opera houses of Vienna were very dependent on the regimental bands for filling up their ranks, but with these changes in these two bands there was only one band which could supply the opera house—a state of things which would not do. The consequence was that the pitch had to be raised by the opera-houses, and that was the beginning of a rise which spread with great slowness and difficulty throughout Europe. In 1820, Sir George Smart, the well-known conductor, proposed they should raise the pitch to A 433. In 1859, the French Commission proposed 435, and, therefore, what we called the French pitch was, practically, the English pitch, which existed unquestioned for so many years in this country, and was known everywhere as the Philharmonic pitch. It was during the time that Sir Michael Costa presided over the Philharmonic Society that the next great rise took place, and it rose, between 1852 and 1874, to a mean of 452½, and to a maximum of $454\frac{7}{10}$. Desiring to find out what was being done at the present day at Vienna, he, on Friday, took the pitch of the band of Herr Strauss, and found that it was exactly the same as they were adopting at the Inventions Exhibition—452, perhaps a fraction of a vibration over; but he was informed at the same time that the opera at Vienna was nearly a quarter of a tone flatter. He afterwards went to the Pomeranian band, and found the pitch was 461. In America the pitch was 458. They thus had all

these varieties. When Wagner was here he complained to Dr. Pole of his singers having to sing so much higher—three-quarters of a semitone—than he had written to; and they knew that Wagner did not spare his voices.

Mr. OTTO GOLDSCHMIDT, Dr. STAINER, Mr. BOSANQUET, and M. DUVIVIER also spoke to the motion, which was carried.

Dr. HOPKINS (organist of the Temple Church) proposed the second resolution, "That in order to annul the great inconvenience consequent on the discrepancy of pitch in this and other countries, it is desirable to adopt the French normal diapason of 518 double vibrations for C, third space in the treble," which was seconded by Mr. C. STEPHENS (treasurer of the Philharmonic Society), and supported by Mr. CURWEN.

After much discussion, and the proposal of an amendment which was negatived, the original resolution was carried.

Dr. STONE moved the third resolution, "That steps be at once taken for securing the adoption of the standard pitch in the principal orchestras; and also, if practicable, by the regimental and other bands of the British Army," and said he did not think they would be justified in asking for any immediate and sudden change in the army, but with the thin end of the wedge adopted, he believed the self-interest of the players themselves would lead them gradually to get their instruments assimilated to the pitch which was generally in use.

Mr. COUSENS (Principal of the Academy of Music at Kneller-hall) thought that numerous meetings should be held on the subject to press the matter on the authorities, but the financial part of the question would be a difficulty for some time.

Mr. BLAKELEY stated that in military bands as they existed there was a very fair standard of uniformity of pitch. An alteration to the Society of Arts pitch was practicable, but he could not agree with Dr. Stone that the alteration to the French normal diapason was practicable except for brass instruments.

Mr. BRINSMEAD would not venture to say what was the best musical pitch, but whatever pitch was chosen could be adopted to pianofortes without the least injury to their qualities of tone, and without much expense.

The resolution was then put and carried, as was a further resolution appointing a committee to fulfil the previous resolutions, and requesting the following gentlemen to serve, the CHAIRMAN stating that they had been selected as physicists, practical musicians, vocalists, composers and players, and instrumental manufacturers:—Mr. Bosanquet, Mr. Ellis, Mr. Hipkins, Dr. Pole, Dr. Stone, Mr. Walter Bache, Mr. Otto Goldschmidt, Mr. Henry Holmes, Dr. Hopkins, Sir G. A. Macfarren, Mr. Walter Macfarren, Mr. Patey, Mr. Sims Reeves, Mr. Sainton, Mr. Santley, Dr. Stainer, Mr. Van Biene, Mr. A. C. White, Mr. Bruzaud, Mr. Blakeley, Mr. Willis, and Mr. Brinsmead.

JAPANESE TECHNICAL APPARATUS.

In the paper recently read before the Society (see *ante* p. 627), by Mr. Henry Cunynghame, on Technical Education, prominence was given to the consideration of the means for providing instruction in physical science without costly apparatus, and the work of Professor Guthrie, at South Kensington, was referred to as an illustration of how it might be done. That ingenious people, the Japanese, have taken up the matter in a very practical way.

The great interest in the apparatus which Japan boys are taught to make, such as was lately shown in London, lies in the degree to which simplicity has been pushed, in the fertility of resource, and the ingenuity and skill displayed. Many a teacher in our elementary schools hesitates to take up the teaching of physics and chemistry on the ground that the apparatus is so costly.

The Tokio school trains teachers to be sent to poor villages, where a collection of apparatus such as still in this country is regarded as a befitting equipment for a laboratory would be out of the question. Hence we see bamboo canes, corks, scraps of wire, old bottles, broken tools, flower pots, in short things that in every village would go to the rubbish heap, utilised for the construction of apparatus. To those who have not seen in the South Kensington Museum what Professor Guthrie's pupils have done, it would appear almost incredible what those Japan boys can do. They do not come up to the South Kensington work in point of finish and elegance, but this is not aimed at. To find the handiest material for doing just what is wanted is the point. No doubt the specimens exhibited in this country are picked, it is natural that should be so, still they are representative. What simpler material for the construction of an electric machine could be thought of than two old beer bottles, one for the cylinder and the other as an insulating stand, a fragment of an old saw, an old bell, some long sharp nails driven in a row, some old handles and other bits of wood? Or, again, for a mercurial air-pump, some short lengths of glass tubing, bottles, a tumbler, sealingwax, string, and caoutchouc? Yet, somewhat clumsy though it looks to our eyes, accustomed to delicate and finished instruments, it illustrates the manner of its acting, even if it should not be capable of working with great perfection. Then there is a simple polariscope, a Coulomb's torsion balance, and a Cartesian diver, consisting of an egg shell, a small

stone, a bottle and cover. A model to illustrate the principle of an equatorial telescope is specially simple. It belongs to another section, but illustrates simplicity. Into the cork of a bottle is put a short piece of wire, on to which is placed another cork. From this springs another wire, on to which a soft wax candle is pushed. Why a bamboo cane is not used instead of a wax candle is not apparent, but the principle is the same.

For chemistry the arrangements are just as simple. A retort stand is made from bamboo, a piece of wire-work ash-sifter for the retort to rest on, and a strip of bent bamboo to form a clip. Where bamboo cane can be used instead of glass it appears to be done; for example, in place of a glass jar with a nozzle for burning hydrogen, a large hollow cane, stopped at one end with a tobacco mouthpiece, is used. This, perhaps, is really hardly so simple though as the usual way of generating the hydrogen in the same bottle as that from which it was burned. Stoneware jars, however, seem in all cases used as retorts, for no glass retort is shown. Teachers often say they cannot show their pupils the decomposition of water; but here is a Buren battery (one "cell" at least), made of a glazed pot, a porous pot, a coil of zinc, and a stick of charcoal. The "collector" is equally home made, except that the two test tubes probably have to be purchased, and these are cheap enough; it is in the putting together the skill lies.

All the rest of the apparatus is equally simple, and all, as it is intended, within the reach of a young teacher going to settle down as schoolmaster in a poor village.

So far, cost only has been spoken of. There is another aspect of the subject, which applies to the study of physics and chemistry, in their earlier stages at least, not only in Japan, but everywhere. In more recondite researches, skilled and experienced manipulators are, without doubt, needed, but that does not affect normal schools. This other aspect is the effect of method of study on the student. When "the natural sciences" were first admitted into the curriculum of our universities, lectures were deemed sufficient. They dealt in generalisations without illustrations of the facts on which the generalisations were based. Then followed the introduction of experiments. But the experience of teachers was that the students might retain general impressions of some of the experiments, or possibly remember some exact wording in which some of the generalisations might be expressed. It was not till Professor Adolf Weinhold's "Vorschule der Experimental-physik" showed teachers how to arrange apparatus, "home-made," for their classes, that the way of getting over the difficulty was made clear. Professor Carey Foster, in his preface to the English edition of this work (1874), wrote, "Hitherto, unless a teacher has been able not only to devise a general plan of instruction, but also to contrive every detail of experimental work, he has had no choice but to fall back on text-books. Now all who wish to adopt a more satisfactory system have a guide. This guide has been followed in England, and the principal of directing students how to devise their own apparatus is on the increase. Priestley, Dalton, Cavendish, Faraday, and other pioneers had to devise theirs, and they often had the homeliest materials. Skilled philosophical instrument makers are needed for delicate apparatus, but it was want of ingenuity that led students to go to them for what they could do themselves. The change has for some years set in, and Japan, in doing what she is, is acting in accordance with the experience of distinguished European teachers. The introduction of the method to Japan was due to two English professors.

General Notes.

Culinary Exhibition at Zurich.—An exhibition of objects relating to the culinary art is to be held from the 15th to the 20th October next, and will be opened to all landlords of hotels, cooks, and restaurateurs, as well as dealers in provisions of every kind. The exhibition will include meat, game, fish, preserves, fruit, vegetables, mineral waters, and every description of provisions, as well as cooking utensils or instruments.

Nuremberg Exhibition of Machinery.—An Exhibition of Machinery for the production of motive power especially adapted for the use of small workshops will be held at Nuremberg from the 15th of July to the 30th of September. The contents of the Exhibition will be divided under three groups—1. Power machines for small workshops. 2. Machine tools for small workshops. 3. Products of small workshops, so far as they illustrate the first two groups.

Railway Construction in Italy. — The longest tunnel in Italy, always excepting that of the Mont Cenis, which is not altogether on Italian soil, is that just opened at Marionopoli, in Sicily, on the direct line from Palermo to Catania. This tunnel, which is not far from Caltanisetta, was commenced in April, 1880, and is 6,482 metres (7084·73 yards) in length, and five shafts of the respective depths of 111·60 metres, 250 metres, 250 metres, 164,47 metres, and 92·02 metres (366 ft., 820 ft., 820 ft., 539·46 ft., and 301·82 ft.) were sunk in order to expedite its construction, which was attended with considerable difficulty, not only on account of the great quantity of water met with, but also from the nature of the ground, which necessitated the tunnel being lined with brick masonry walls and arch.

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FRIDAY, JULY 3, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by permission of the Executive Council of the International Inventions Exhibition, in the Exhibition Buildings, this evening (Friday), 3rd July.

Proceedings of the Society.

CANTOR LECTURES.

CLIMATE IN ITS RELATION TO HEALTH.

By G. V. Poore, M.D.

Lecture I.—Delivered January 12, 1885.

It seems necessary, to begin with, to offer some definition of the word "Climate;" and yet, as we all know pretty well what we mean by climate, it is perhaps hardly advisable that I should fetter your ideas by any hard-and-fast definition, and I am sure that it is not advisable that I should fetter myself, for I intend to treat of climate in the freest manner possible, and I must by anticipation ask your indulgence for many divergencies from the conventional ideas of "climate." The definitions given by Dr. Hermann Weber, in the second volume of Von Ziemssen's "Handbuch der allgemeinen Therapie," is probably wide enough for all purposes, and although I do not promise to be bound even by it, I offer it as a sort of foundation upon which to build my remarks. Dr. Weber says, "By climate we mean the sum of those influences which act upon the life of organic beings through the air, soil, or water of a district."

The earth is surrounded by a gaseous envelope, having a depth, it is supposed, of some forty miles. Crawling at the bottom of this ocean of air is man, who may be likened to a crustacean crawling at the bottom of the sea. Some animals there are—birds, insects, and the like—which are able to live in the higher, purer regions of the atmosphere. Man crawls along the bottom, and lives in the lowest strata, which are often rendered cloudy by the dust of various kinds, which is raised by himself and his teeming fellows. Life without the atmosphere is inconceivable. Not only does it minister to those chemical changes which are constantly going on in the body, and the cessation of which means death, but the pressure which the atmosphere exerts on our bodies (varying from twelve to fifteen pounds per square inch of surface, according to the elevation above sea level) is probably essential for the well-being of our bodies as at present constituted. Without the atmosphere, the evaporation of water and its re-condensation in the form of dew, rain, and snow would probably cease; and, finally, without the atmosphere, which is spread like a transparent curtain between us and the sun, not only would the sun's rays be perfectly insupportable, but the transitions of temperature would have a suddeness and severity to which it would be impossible to accommodate outselves.

The atmosphere is almost uniform in composition. In 100 volumes of air there are of—

Nitrogen	79·00	volumes.
Oxygen	20·96	,,
Carbonic acid....	00·04	,,
	100·00	

Of these gases the oxygen is the most important. It is the great supporter of life, the gas that carries on the combustion of the human body, that maks the flame of life burn brightly, that calls forth the energy of the animal machine, and enables us to maintain our body temperature in all weathers.

Since we breathe some sixteen times in a minute, and inspire about a pint of air every time we draw our breath, it is evident that the amount of air we require per diem is prodigiously great, and that the purity of the air we breathe is a matter of prime importance.

Whence come the gases which form the chief constituents of the atmosphere? Of the source of origin of the nitrogen we know nothing. Of its uses we know nothing.

Its chemical action in the great function of respiration appears to be *nil*, and, although it constitutes nearly four-fifths of the total bulk of the air we breathe, its properties seem to be to a great extent negative. Even supposing that its main function be to diffuse and dilute the oxygen, we must be careful not to underrate such a function.

The main source of carbonic acid is the respiration of animals and other forms of combustion. The air we breathe returns from our lungs highly charged with carbonic acid and moisture—too impure to breathe a second time. Countless millions of animals, high and low in the scale, are engaged in fouling the atmosphere, and in pouring carbonic acid gas into it, and at the same time in using up the oxygen. If, then, every creeping thing that lives upon the globe is constantly using up oxygen and giving off carbonic acid, the question arises, how is the oxygen renewed, and how is the carbonic acid got rid of? The answer is that vegetable and animal life are complementary to each other, and that every green leaf of every waving forest tree, every blade of grass that clothes the sward, every green seaweed and river weed, is actively engaged in absorbing carbonic acid from the air or water, fixing the carbon, and returning the oxygen to the air for the benefit of animals. Thus carbonic acid is constantly being given off by one class of organisms (the animal), and greedily devoured by the other great class of organisms (the vegetable), while the oxygen given off by the vegetables is devoured by the animals.

If the renewal of the chief constituents of the air is thus provided for, it is still not at first obvious why it is that the air is almost uniform in composition. In some places, as in this great overgrown city, for example, animals are greatly in excess of vegetables, and we should expect to find that, in the air of London, there was great excess of carbonic acid. Excess there is, but not to the extent that we should have perhaps imagined.

The almost uniform composition of the air is accounted for—

1. By the equal distribution (taking the whole world over) of animal and vegetable life, the animals living to a great extent on the excremental gas of vegetables, and *vice versâ*.

2. By the law of diffusion of gases.

3. By the movement of the air produced by local and meteorological causes. Besides the incessant local movement produced by the movement of animate and inanimate objects, variations in temperature and consequent variations in pressure, there is the general movement of the wind to be considered, and this, be it remembered, has a general average rate of speed in this country of ten miles an hour.

Thus the mixing of the gases is very thorough and very constant; and when (also) it is borne in mind that at the average rate of speed of the wind as much air blows over the surface of a man's body as would, at a pinch, serve for the respiratory need of 1,000, and that the supply of air is thus in great excess, and that the fouling of the atmosphere by animals is, in proportion to the whole bulk of the atmosphere, but trifling, we begin to see how it is that, in the open, the composition of the air very nearly approaches uniformity.*

The uniformity is, however, very far from being absolute. Thus, if we take the average amount of oxygen as 20·96 volumes in every 100 volumes of air, or 2,096 in every 10,000, we find that in the thickly-populated parts of the East-end of London it may fall to 2,086 parts per 10,000, while on the high ground to the North-west of the City it may rise to 2,100 parts per 10,000, which is in fact as much or more than Angus Smith found on the hills in Scotland. Thus the extreme range of fluctuation in the amount of oxygen in the open air is about fourteen parts in 10,000, or ·14 per cent.

I am not prepared to say that fluctuations of this kind have any appreciable effect on health. When we speak of air containing 21 parts per cent. of oxygen, we mean volume, not weight, so that this expression gives us no idea of the absolute amount of oxygen inhaled. Equal weights of gas or air are capable of occupying very different volumes, according to the temperature and pressure to which they are subjected. The effect of temperature is thus stated in a foot-note to Parkes's "Hygiene,"

* Professor de Chaumont, in his admirable lectures on "State Medicine," makes the following interesting and curious calculation:—"Now I reckon that at the lowest estimate there cannot be less than 300,000,000,000 cubic feet of carbonic acid generated in London in a year from combustion and respiration, or a mean of 822,000,000 per day or 34,250,000 per hour, or more than 9,500 cubic feet every second. Now, this is sufficient to double the normal amount of carbonic acid in 23,750,000 cubic feet of air every second, or in about 14 cubic miles every twenty-four hours, or more than 5,000 cubic miles per annum. This represents a mass of air of the area of the metropolis, but extending upwards to ten times the height of the Himalayan mountains. How constant and powerful must the varying currents be that produce diffusion through so vast a mass."

p. 436. "A cubic foot of dry air at 30° Fahr. weighs 566·850 grains, and is thus constituted—

436·475 grains of nitrogen.
130·375 ,, of oxygen.

At a temperature of 80° Fahr. the foot of air weighs 516·38 grains, and is thus composed—

397·61 grains of nitrogen.
118·77 ,, of oxygen.

516·38

Thus, at the higher temperature (80° Fahr.), each cubic foot of air contains 11·605 grains of oxygen less than at the lower temperature, and if we assume that the rate and depth of respiration is the same at the two temperatures, and if we further assume that 16·6 cubic feet of air are drawn into the lungs every hour, then the man in the tropical temperature, as compared with the man in the Arctic temperature, will have, so to speak, an hourly deficit of oxygen amounting to 192·6 grains.

The fire burns bright, we are told, in frosty weather, the reasons being, firstly, that those who have the care of the fire, and are themselves nipped by the frost, take care that it shall burn brightly; and secondly, the cold air which supports the combustion is rich in oxygen.

One of the great objects of respiration is to support the animal heat, and it is only one of the many instances of the absolute adaptation of means to ends which we meet with everywhere in nature, that the man who is exposed to cold is supplied with increased amount of oxygen, to cause a brisk combustion in the human furnace; while he who is scorched by the sun, and has less need of internal fire, gets a diminished supply of oxygen.

Again, diminution of pressure lessens the amount of oxygen in each cubic foot of air. If we ascend a mountain 5,000 feet high, the barometer will fall from 30 inches to 25 inches, *i.e.*, the pressure will be diminished one-sixth, and a cubic foot of air, which contained 130·4 grains of oxygen in the valley, will contain only 108·6 grains at the higher level, or a diminution of 21·8 grains per cubic foot. If we assume the rate and depth of respiration to be unaltered (which we have no right to do) then the deficit of oxygen at the higher level per hour amounts to $21·8 \times 16·6 = 361·88$ grains. These figures show that man is able to bear very great fluctuations in the weight of oxygen in the air which he breathes. They show certainly more than this, viz., that fluctuations in the amount of oxygen are necessary for his well-being under variations of temperature and pressure. Why it is that less oxygen is required to support life at great altitude is not very clear, but when we look at the hardy mountaineer, the type of health and manly beauty, we must admit that the fact is undeniable.

Although we are, at present, unable to say that the mere fact of a small per-centage variation of oxygen in the air breathed is, by itself, a very important matter, still we have to remember that it is never an isolated fact, and has always to be considered along with other facts. What we have to look to is the reason why a diminution has taken place.

Whether the small amount of carbonic acid (·04 per cent. by volume) which is present in the air serves any useful purpose in the animal economy, it would be difficult to say. Carbonic acid is regarded as an impurity, an impurity poured into the air as the result of respiration and combustion.

In the open air the amount is not found to vary to any very great extent, as the following list will show:—

Carbonic Acid, per Cent.

Over open sea (Thorpe)		·032
At Manchester (A. Smith)		·037
At Portsmouth (De Chaumont)		·032
At Aldershot	,,	·040
At Tower of London	,,	·042
At Chelsea	,,	·047
At Paddington	,,	·056
At Munich (Pettenkofer)		·050
Top of Mont Blanc (Frankland)		·061
At Chamonix	,,	·063
Arctic Regions, *Alert* (Moss)		·055

It is well known that carbonic acid in large quantities is a narcotic poison. An atmosphere containing from 5 to 10 per cent. (*i.e.*, 100 to 200 times the amount in ordinary air) is fatal. It is stated that in soda-water factories, where the amount of carbonic acid often reaches ·2 per cent., no ill-effect is felt.

The variations in the carbonic acid in the air are not very great; and it is probable that variations such as those shown above of carbonic acid per cent., would be incapable of working much, either for good or ill, but it must be remembered that carbonic acid always keeps bad and dangerous company; and when the chemist tells us that in such or such a place carbonic acid which he can analyse is in excess, we may feel sure that it

is accompanied by organic matter which he cannot analyse.

In confined spaces where human beings or animals are closely packed, carbonic acid is found in great excess. In the forecastle of a ship, the almost incredible amount of 3 per cent. of carbonic acid has been found by Rattray, and the average of 150 analyses made between decks gave 1·64 per cent. of carbonic acid. These figures are the highest which have been obtained in any place which is inhabited and inhabitable, and the explanation is to be found in the small cubic space per head, and the constant occupation of the space day and night. As much as ·58 have been found in theatres; ·70, ·50, ·30 have been found in crowded schools; ·20 in bedrooms; and similar amounts in hospitals, prisons, and other crowded places.

When the carbonic acid in a room is due to respiration, it is accompanied by a larger amount of organic matter given off by the lungs and skin, and this organic matter is but too plainly perceptible to the nose in overcrowded apartments. It is said that when in a crowded room the carbonic acid reaches ·07 per cent. the air smells no longer fresh, and that as the carbonic acid increases the foulness of the air steadily increases, till it becomes almost unbearable.

It is this organic foulness which we have mainly to fear in overcrowded places. It was the organic foulness rather than the carbonic acid which killed the victims of the Black Hole of Calcutta, and which caused symptoms of blood poisoning in those who survived. The chief sources of carbonic acid are—

1. Respiration.
2. Combustion.
3. Putrefaction.

With regard to ozone, a great deal has been said, but in reality very little is known. It is an allotropic form of oxygen, possibly nascent oxygen freshly evolved from the green leaves of plants. It has great power of oxidation (it is said), and great power of destroying organic manner. It is usually absent in the air of towns, and present in the fresh air of the country. Its absence seems to show that the air has been, to a certain extent, used.

Taking the two chief constituents of the air—oxygen and carbonic acid—we have seen that, in the open air, their relative proportions differ so little that it is impossible to believe that the slight variations in the amounts found can ever be considered as elements of climate of any importance. The truth of this is made apparent, because we have seen that variations of temperature and pressure cause most important variations in the amount of oxygen inspired; and we have abundant proof that the highest degree of health is compatible with these variations.

Please take note that I am speaking of the open air; I leave the interior of dwellings out of consideration. Even in the best ventilated dwellings the quality of the air is far below that in the open country, or the open street; while in badly-ventilated or overcrowded dwellings, the air is actually poisonous—poisonous not merely because the carbonic acid has reached a high per-centage, but rather because this carbonic acid, being due to respiration, is accompanied by odoriferous organic matter, of which we shall have more to say hereafter.

The air usually contains other chemical imgredients. Traces of common salt and ammonia are always to be found, and in the air of cities, carbonic oxide, hydrochloric, sulphuric, and sulphurous acids, in greater or less quantity. It is these latter gases which prove so deadly to all kinds of vegetation in London and other large cities. They result from the combustion of fuel and gas, and are present in such quantity that the rain which falls through the lower strata of the London atmosphere is generally strongly acid, and often proves destructive to tender plants which are heedlessly left exposed to a shower ignorantly thought to be freshening.

It is the acid in the air of London which proves so destructive to most metals, which blackens the silver, corrodes the metal fittings of our houses, gives a worm-eaten look to some of our statues, and is causing the crumbling of what is still called the New Palace at Westminster. What the effect of this acid condition of the air is upon human beings we have no exact knowledge, excepting that in cold, still weather, the mortality from lung disease in this overgrown town is apt to become almost appalling.

This condition of the air is, after all, you will say, only a local condition, and has no right to detain us in a discourse on climate which should include only conditions affecting countries or large districts. This is very true; but if the acid condition of the London air is a local condition, it is a local condition which affects a vast population, and is, therefore, of great importance.

Of the gaseous constituents of the atmosphere which we have mentioned, the oxygen,

nitrogen, and carbonic acid alone are constant and universally present.

There is yet another gaseous element of the atmosphere which is absolutely universal, although the amount which is present varies immensely under different conditions. This is watery vapour.

Although this vapour is invisible, we are constantly being reminded of its presence. The moisture that condenses on the cool window panes of a crowded room, or that dims the surface of the tumbler of iced water which one may be lucky enough to get at some suffocative dinner, are among the every-day evidences that watery vapour is present in the air, and ready to condense.

Air is only capable of keeping a certain definite amount of watery vapour in an invisible condition. For equal barometric pressures the amount varies with the temperature. The higher the temperature, the greater is the amount of vapour which the air will hold invisible. At a freezing temperature each cubic foot of air will hold just over two grains of watery vapour, while at a temperature of 100° Fahr. the amount which the air will retain is close upon twenty grains, or ten times as much. These figures are not precisely accurate, but they are near enough for our purpose, and are easily remembered. When the air contains its maximum amount of watery vapour (an amount which increases with the temperature) it is said to be saturated, and if saturated air be cooled the moisture is deposited in the form of dew.

Rain, in like manner, is caused by the cooling of air saturated with moisture.

According as the moisture in the air falls short of saturation, so is its drying power, and its power of causing the evaporation of fluids. If complete saturation be spoken of as 100°, then the relative humidity of the air may be stated as a per-centage of the maximum. Let us suppose that a cubic foot of air contains 50 per cent. of watery vapour. If the temperature of the air be 32° Fahr., then we shall know that each cubic foot (containing 50 per cent. of its maximum) holds about one grain of watery vapour, and is capable of drying up a second grain. If the temperature of the air, however, be 100° Fahr., we shall know that each cubic foot (containing 50 per cent. of its maximum) holds about ten grains, and that the drying power of each cubic foot is equal to another ten.

Now it is important to bear in mind that although the air in both these imagined instances has a humidity of 50 per cent., yet the drying power is ten times greater at the higher temperature.

Since the drying power, *i.e.*, the power of causing evaporaton, is that which exercises most influence on our health and comfort, it follows that humidity must always be considered in conjunction with temperature. When the drying power of the air is great, the evaporation of fluid from our skins and lungs is great. When the drying power of the air is small, the evaporation of moisture from the skin and lungs is small also. It follows from this that a dry air is often of great use to persons suffering from what are known as chronic catarrhal conditions of the respiratory passages (throat, nose, windpipe, and bronchial tubes). The moist mucous surfaces of these parts are, as it were, dried up by the dry air which is drawn over them, and the sufferings of the invalid are greatly lessened.

As regards the effect of the drying power of the air upon the skin, it is quite impossible to consider it apart from the question of temperature, because the amount of perspiration to be evaporated depends mainly upon the temperature (exercise being left out of consideration), and hence it follows that the amount of perspiration to be evaporated may be ahead of the drying power of the air. Hence, it is not possible to consider the effect of drying power on the skin apart from the question of temperature, and we must therefore defer it until we come to talk of temperature.

The moisture in the air is due to the evaporating power of the sun. The heat of the sun is constantly raising water in the form of vapour; just as the water in a boiler is changed to vapour by the glowing fuel. In tropical regions the amount of water which is changed to invisible vapour is prodigious, but the evaporation in temperate climates is also very great, for it must be remembered that this evaporation goes on so long as the moisture in the air falls short of saturation.

The watery vapour in the air is of the greatest importance from a meteorological, and, therefore, indirectly from a climatic point of view. Mr. Scott, in his work on the "Elements of Meteorology," thinks that the distribution of moisture in the air is very local, and depends, to a great extent, on the proximity of free water surfaces to supply the moisture. It is, therefore, great in the air over tropical seas, slight in the air over extensive tropical deserts. The amount of moisture is generally

more or less in direct relationship with the temperature. The dryness of the air during a Canadian winter is well known. The water, is, to great extent, locked up in solid form, and the evaporating power of the air is slight, and hence the dry crisp atmosphere, of the pleasures of which we hear so much. The amount diminishes as we ascend in a degree rather more than proportionate to the fall of temperature. The air of high mountains is relatively dry, but the degree of moisture follows no regular law, and it has been observed by balloonists, as well as mountaineers, that in ascending to great heights, strata of air of varying degrees of moisture are passed through.

The watery vapour ever present in the air acts like a garment to the earth, an invisible robe protecting the surface of the earth, on the one hand from the scorching influence of direct solar radiations, and on the other hand preventing, to a great extent, the radiation from the earth itself, and the too rapid loss of heat when the sun goes down.

Like our own garments, the invisible watery garment of the earth moderates the heat and cold, and tends to produce equability of climate. In situations where the moisture in the air is slight, the extremes of temperature are excessive, as in flat sandy deserts, and on mountains; the heat of the sun in these situations being in striking contrast to the bitter cold of the nights.

The watery vapour ever present in the air may become visible. Were I to bring a glass of ice-cold water into this room, its surface would be dewed with moisture, because the air in contact with the glass being suddenly chilled, its capacity for moisture is lessened, and a part of it is deposited.

When the surface of the earth is suddenly chilled by radiation, dew is in like manner deposited from the strata of air in contact with it. When a clear night succeeds a hot summer day, the deposit of dew is always (in this climate) very large. Dew, it will be noticed, is always most abundant on grass and herbage, on the leaves and stems of trees, on wood and metal work, &c., while it is not present on gravel walks and in dusty roads. Dew is, in short, deposited on those bodies which lose their heat most readily by radiation.

The heaviest fall of dew which it has been my lot to witness was on a winter's morning in January, on board a yacht off Cagliari, in the Island of Sardinia. I was roused about half-past seven by the pattering, as I thought, of heavy rain upon the deck, but on going on deck I found that the shower was exceedingly local, being produced by the deposit of dew upon the high spars and rigging of the yacht, and its subsequent descent upon the deck in a heavy shower. The power of the sun on the previous day had been very great, and had raised much vapour from the sea, and this moisture-laden air being cooled by contact with the cold spars and rigging, discharged its moisture in the manner related.

Humboldt has recorded how, in some of the forests of South America, the traveller on entering a wood finds, apparently, a heavy shower falling, whilst overhead the sky is perfectly clear. The formation of dew takes place on the tops of the trees, and so copiously, owing to the abundance of vapour in a tropical atmosphere, that a real shower of rain is the result.

Fogs and mists are due, it is now generally supposed, to the condensation of moisture on the infinitely fine particles which are always suspended in the air. If the air be absolutely free from dust, watery vapour forms no mist, but the presence of solid impurity determines a fog. For the formation of fog three things are necessary:—

1. The cooling of moisture laden air.

2. Calm weather, so that the mist is not blown away as soon as formed.

3. Solid matter in the air.

When in winter the south-east wind blows, bringing moisture-laden air from the German Ocean and the Channel, up the estuary of the Thames, and when this moist air comes in contact with the cooler air of London, charged with solid impurity to an enormous extent, a London fog is the result. The fogs of Newfoundland are due to the chilling of moist air by coming in contact with a surface of water cooled by melting ice.

Most of the water evaporated from the surface of the salt and fresh waters of the globe returns to the surface in the form of rain.

Rain is produced by the chilling of air more or less charged with moisture. Near the equator the hot air charged with moisture rises into the cooler regions of the atmosphere, and descends again as rain, and in torrents of which we have no knowledge in these latitudes. Air which has traversed a large tract of sea, like that which comes to us from the south and west from off the surface of the Atlantic, is charged with moisture. As it strikes against the precipitous hills of our western coasts, it is chilled by the colder land, and, at the same

time, is driven upwards by the conformation of the hills, and the result is that the moisture is deposited in the form of rain. Hence it follows that the south-west corner of Ireland and the western coast of England and Scotland are the wettest parts of the British Isles, and in great contrast to the eastern coasts.

The wettest parts of the globe are those where winds blowing from tropical seas strike against the chilled tops of high mountains, and probably there is no place with greater rainfall than the district which lies at the eastern extremity of the Himalayan mountains, where the rainfall is said to amount to as much as 400 inches a year.

Winds laden with moisture lose it at the first opportunity. Thus the south-west winds in this country cause heavy rainfalls on our western coasts, amounting to as much as 150 inches per annum in some parts of Cumberland. The winds, thus dried by a fall of rain, can cause but little rainfall elsewhere, so that in our eastern coasts the rainfall is not more than 20 inches.

The centre of great continents are necessarily dry. The middle of Australia, Sahara, in the centre of Africa, and parts of Central Asia, are among the driest regions of the world.

What are the effects of moisture and dryness?

It is a well-known fact that when water is evaporated and turned into invisible vapour, that a certain amount of heat becomes latent, as it is termed, and cold results. When, on the other hand, watery vapour is condensed and becomes liquid, the latent heat is given out, and hence rain has a great power of warming the air. Professor Haughton has calculated that, on the west coast of Ireland, the heat derived from the rainfall is equal to half that derived from the sun.

The presence of rain-clouds has, of course, a great influence on the temperature of a district, as, by obstructing the sun's rays, they prevent the heating of the surface.

On the other hand, clouds equalise the temperature by preventing radiations of heat after sunset. Cloudless nights are cold nights, because of the comparatively unobstructed radiation. These are the nights when the gardener covers up his tender plants, and looks to his greenhouse fires. Cloudy nights, on the other hand, are warm.

Rainfall has a very purifying influence on the air, by washing it of its solid and some gaseous impurities. Who has not watched a thunder shower after a spell of dry weather in London, in July or August? Previous to the shower the air is oppressive, and has a smoky ammoniacal smell, and the wooden pavements, kept moistened by the watering carts, smell like a stable. With the first drops of the shower, "blacks" as big as blue-bottle flies are driven downwards from the upper strata, these diminish as the shower continues, and soon the air smells fresh and wholesome.

As to the effect of moisture upon health, not very much is known.

Rainfall purifies the air, and if it be not sufficient to prevent exercise it apparently does no harm. When the air is hot and moist, so that evaporation, with its consequent cooling, cannot be effected on the skin, it is very oppressive. Moist air is most grateful to persons with dry chronic coughs.

There is one way in which moisture affects health, and which has been not much considered hitherto, and that is the effect which it has on the process of decay and putrefaction. Putrefaction, as is well known, is favoured by warmth and moisture, and is checked by cold and dryness. Warmth and moisture for the most part favour the growth of bacteria and other allied micro-organisms, some of which are definitely known to be directly connected with epidemic disease, while cold and dryness check them.

Parkes ("Practical Hygiene," page 37) remarks:—

"The spread of certain diseases is supposed to be intimately connected with the humidity of the air. Malarious diseases, it is said, never attain their fullest epidemic spread, unless the humidity approaches saturation. Plague and small-pox are both checked by a very dry atmosphere. The cessation of bubo plague in Upper Egypt after St. John's-day has been considered to be more owing to the dryness than to the heat of the air.

"In the dry Harmattan wind on the West Coast of Africa, small-pox cannot be innoculated, and it is well known with what difficulty cow-pox is kept up in very dry seasons in India."

If infective disease be due to organisms, and if the growth of these organisms depends upon conditions similar to those that regulate the activity of putrefaction and fermentation—facts in which there is a daily increasing belief—then we must come to the conclusion that dryness and cold both check one class of diseases, and that the biting dry east winds in this country, and the much abused north-west wind which is known as the mistral in the south of France, are, although pitiless,

and indeed often deadly to the sick and weakly, among our best friends from the point of view of health.

From the point of view of exercise and comfort, the absolute annual rainfall of a district is of less importance than the number of rainy days per annum. There is no necessary relationship between the annual rainfall and the number of rainy days; in fact, they often bear an inverse proportion to each other.

If we propose to visit a particular spot in search of outdoor exercise, pleasure, and health, this point of the number of rainy days to be expected is one of very great importance. Thus, at Valentia, on the west coast of Ireland, with a very mild even temperature, some 235 wet days per annum may be expected. According to Hassall, who is quoted by Weber, there is, at Torquay, an average rainfall of 36 inches, with 200 rainy days; at Ventnor, 34 inches, with 174 rainy days; at Cannes, 35 inches, with only 70 rainy days; at Bournemouth, 28 inches, with 156 rainy days; and at San Remo, 28 inches, with only 48 rainy days.

Although I have no doubt these figures give a fairly correct notion of the relative raininess of the places mentioned, we must, nevertheless, be careful how we build our hopes upon average numbers. The average is sometimes calculated upon too small a number of years. Sometimes the years upon which the average is calculated are, so to say, picked, and the calculation, actuated by local bias, has begun with the year after, and stopped short of a year when some extreme number has been reached. Even supposing that the averages are in every way just, we must still remember that there are extremes as well as means, and we may have the bad fortune to visit a spot with a dry reputation and get a daily drenching. Such was my luck at San Remo, in the month of February, 1883.

Having considered the atmosphere—its gaseous and watery constituents—in its relation to climate and health, we now turn to something which is, as it were, outside of and independent of the atmospheric garment in which the earth is clothed, but which influences us mainly through the instrumentality of the atmosphere. I allude to temperature.

The main source of the earth's heat is the sun, which is distant from us some 92,000,000 of miles, and it is worthy of remark that, owing to the elliptical orbit of the earth, we are about 3,000,000 of miles nearer the sun at our mid-winter than we are at our mid-summer. It is evident, therefore, that the seasonal variations of temperature do not depend on the varying distance of the sun.

The seasonal variations of temperature depend on the verticality or obliquity with which the sun's rays strike the surface of the earth, for the more vertical is the path of the sunbeam the more concentrated is its effect, and the thickness of atmosphere which it has to traverse is at its minimum. When the sunbeam falls obliquely its effect is more dispersed, and the thickness of atmosphere which it has to traverse is at its maximum. Therefore, when the sun is most vertical, *i.e.*, at Midsummer, and at midday, we derive most heat from it, and when the sun is "low in the heavens," as at mid-winter, and at dawn and evening, we derive less heat.

Much of the radiant heat of the sun is absorbed by the watery vapour of the atmosphere before it reaches the earth. The greater part of this absorption takes place in the lower strata of the atmosphere, and it is well known that, as we ascend out of the lower strata into the dry rarified air of high mountain ranges, the radiant heat derived from the sun is excessive.

The direct radiant heat of the sun passes through the atmosphere without materially raising its temperature, but the temperature of any solid upon which the heat rays fall, such as the soil, the human body, or the blackened bulb of a thermometer, is materially raised. In this country temperatures of 150° Fahr. have been marked by blackened thermometers in vacuo, and in situations where the atmosphere is very dry and very rarefied, "as at Leh, in Ladakh, to the north of Cashmere, at an elevation of 11,000 feet, the readings have gone up to 214° Fahr., and even higher." (Scott, "Elementary Meteorology," p. 56).

"It is a well-known phenomenon that, at considerable elevations above the sea-level, where the denser and damper portions of the atmosphere is beneath us, the direct effect of solar heat is quite disproportionate to the temperature of the air. In such localities, as for instance, at Davos, in Switzerland, at the level of 5,000 feet, you can sit in the sun comfortably without a great coat; while in the shade close by, the temperature is several degrees below the freezing point. In high latitudes the same paradox is observed where the extreme dryness of the atmosphere is due to intense cold. The observation is as old as the time of Scoresby, that on board a whaler you may see the pitch bubbling out of the seams of the ship where the sun shines on

them, while ice is forming on the sides of the ship which is in the shade." (Scott, *loc. cit.*)

In this damp climate, we have hardly any knowledge of the difference which may exist between the temperatures of sunshine and shade, and the difference is one of the first novel experiences of those who visit sunny dry climates, whether at great elevations or elsewhere. In the south of France, along the Riviera, where the air is much drier and the sun more powerful than here, during the prevalence of the dry, cold mistral, to step from sunshine into shade is almost like stepping into a cold bath; and at Marseilles, on one occasion, I well remember standing with my back to the sun until the calves of my legs were fairly scorched with the heat, while my toes, which were in the shadow of my legs, were uncomfortably nipped with the cold.

It is evident that British visitors to these climates run great risks of catching cold, because the sudden alternations of temperature are phenomena to which they are entirely unaccustomed. They are apt to be too lightly clad, and to forget that while the direct rays of the winter sun afford a temperature which reminds us of our July, cold, as severe as that which we experience at home, is lurking in the shade.

The most characteristic feature in the dress of the inhabitants of Southern Europe is the loose, full cloak, so arranged that it may be discarded, or made to closely enwrap the body at a moment's notice. Necessity is the mother of invention, and this cloak has been necessitated by climates in which the alternations of temperature are sudden and severe.

Since radiant heat experiences most difficulty in traversing the damp lower strata of the atmosphere, it follows that its effects are less felt in the neighbourhood of large surfaces of water, where the air is always humid, than elsewhere; and insular climates are, as a rule, less hot than the climates of adjoining continents.

The radiant heat having penetrated the atmosphere, in greater or less quantity, according to circumstances, some of which we have alluded to, what becomes of it?

1. Some of it is absorbed by the surface upon which it falls.

2. Some of it is reflected back, and these reflected rays, added to the direct rays, very much increase the heat of solid bodies exposed them.

The power of the earth to absorb heat varies very much, according to the nature and aggregation of the soil. Assuming the maximum absorbing power to be equal to 100, then Schubler has calculated that the absorbing power of—

Sand, with some lime	=	100
Pure sand	=	95·6
Light clay	=	76·9
Heavy clay	=	71·11
Fine chalk	=	61·8
Humus	=	49

Herbage of all kinds lessens the heat-absorbing power of the soil.

Colour makes a difference to the absorbing power also, and, generally speaking, dark coloured soil and surfaces absorb much heat. Soil and surfaces not only absorb heat but reflect it also, and it may be said that the amounts of heat absorbed and reflected by any surface bear an inverse proportion to each other. Among reflectors of heat which will occur to all, are snow, water, and white chalk cliffs and rocks of all kinds; the presence of these reflectors necessarily intensifies the power of heat upon an individual, or any object capable of absorbing it.

Soils and other surfaces, which have been warmed by absorption of heat during the hours of sunshine, lose this heat again by radiation during the night. Radiation is helped by a clear, dry, atmosphere, and is impeded by a moist atmosphere, or by a canopy of cloud which checks it almost entirely. As a rule, it may be said that soils lose heat by radiation sooner than they gain it by absorption. Soils and solids generally are quickly heated, and quickly cool again.

With water it is different, and seeing that this earth's surface is mostly water, it is very important that we should consider the effect of heat upon water.

In the first place, the atmosphere over the sea or large sheets of water is always more or less charged with moisture. Hence the heat-rays have some difficulty in penetrating the atmosphere to reach the water, and the water, when once heated, experiences from the same cause, so to say, a difficulty in losing its heat by radiation. Again, much of the radiant heat which falls upon the surface of the sea is reflected, and not absorbed.

Thus we have given two reasons why the surface of the sea is not so readily heated as the surface of the soil. Further than this, we have to consider that the heat rays penetrate to a considerable depth into the water, some

600 feet, and do not, so to say, waste all their energies upon the surface.

Lastly, and most important, the specific heat of water is very high, about four times greater than that of land; and for the heating of equal bulks much larger quantities of heat are necessary in the case of water. The heating of water is much slower than the heating of land, and it loses its heat by radiation much more slowly, and for the following reason:—As the layers of water on the surface cool, they get heavier and gradually sink, and warmer water rises to the surfaces. Hence it follows that the sea never gets heated to an excessive extent, and on the other hand, owing to the circulation of the fluid, it never gets chilled to an extent at all equal to the neighbouring land. In polar regions, when water ceases to be liquid, these conditions cease. The sea is, therefore, a great cause of equable temperature, and on its surface and by its shores it may be laid down as a rule that extremes are moderated.

The temperature of the surface of the sea in the tropics reaches about 85° Fahr. as a maximum, while the surface temperature in these latitudes fluctuates between 60° Fahr. as a maximum, and 35° Fahr. as a minimum. If we change the temperature of part of a volume of water, we cause changes of density, and, as a consequence, movement of the mass. Hot water rises, cold water flows in to fill its place. What happens to the oceans which lie between the blazing tropics and the frozen poles? These great masses of water obey physical laws, and there is a constant stream of cold water at the bottom of the ocean, flowing from the poles to the tropics, and, broadly speaking, a flow of warm water on the surface in the opposite direction.

The heated water of the surface not only flows to take the place, as it were, of the sinking cold water of the Poles, but it is blown by prevailing winds, and gets a direction in this way or that by the shape or bendings of neighbouring coast lines. In these islands we ought to be deeply grateful to ocean currents. The general oceanic circulation, and the so-called Gulf Stream, which is in fact a part of it, laps our coasts in warm water, and prevents us from experiencing the wintry rigours which are felt in Upper Canada and Central Russia, places in the same latitude as ourselves.

With this short review of the causes of variations in temperature, we may now particularise a little, and discuss the causes which affect the temperature of localities.

1. *Latitude.*—The length of daily exposure to the sun's rays, and the degree of obliquity or verticality at mid-day, are important elements in determining the temperature of a place. If the surface of the earth were uniform, then latitude and temperature would be in exact relation, but this we know is very far from being the case.

2. *Elevation above Sea Level.*—As we rise above the surface, the temperature of the air falls about 1° Fahr. for each 300 feet of ascent. Hill stations are, therefore, always cooler than stations situate in the plains of the same latitude.

3. *Amount of Cloud and Moisture in the Air.*—These serve as curtains against the sun's rays, and depress the temperature while the sun is shining. On the other hand, they check radiation when the sun has set, and preserve the warmth at night.

4. *The Nature of the Surface.*—Land heats and cools far more readily than water, and, therefore, in the centre of great continents extreme fluctuations are common. The nature of the soil is of importance, as we have seen. The sea moderates temperature, preventing excessive heat, and the extremes of cold. The stretch of water between these islands and the Poles helps to keep them warm, and moderates the bitterness of northern winds. The warm currents from the equatorial Atlantic help also to keep us warm. In Canada and Russia, which enjoy neither of these advantages, the winters are in great contrast to our own.

5. *Prevailing Winds.*—In this climate the south-west winds, laden with rain, are a great cause of warmth, and produce the high winter temperatures of Valentia, on the west of Ireland, of Scilly, and of the islands on the west of Scotland. As a contrast to these places in our own country, let us take the city of Turin, which enjoys a greater sun exposure it is true, but which is exposed to the bitter winds blowing from the snow-clad Alps, and where the serene skies of winter allow uninterrupted radiation of terrestial heat.

6. *Position of Hills and Mountain Ranges in respect of Locality.*—If the hills are between the locality and the sun, they help to depress temperature. We all know the difference between a northern and a southern exposure. If the hills protect the locality from cold winds, and help to reflect the sun's rays, then they increase the temperature of the locality.

Having got so far, it will be well to take a familiar example, and inquire the cause of the climate of one very well known place.

Let us look at that favoured spot in the south of France, known as the Riviera, where our countrymen flock in search of pleasure and of health, of warmth, sunshine, and natural beauties. The climate of this spot, be it observed, is warmer and more equable than that of places farther south, such as Florence, or even Naples, so that its climatic advantages are by no means entirely due to latitude. The sun is more powerful than with us (for the locality is some eight or nine degrees south of London), and in the winter remains somewhat longer above the horizon, so the intensity and the length of sunshine is greater than here. There is far less cloud, and the prevailing winds are less moist, so that the power of the sun's rays to penetrate the atmosphere is greater than here. The soil is dry, and this aids in producing a comparatively dry air, the moisture amounting to about 70 per cent. as against 90 per cent. in London. At a varying distance from the shore are the lower spurs of the range of hills known as the Alpes Maritimes. These serve a double object (1), they protect the locality from the cold winds which blow from the ice-fields of the Alps; and (2), they reflect the sun-heat just as a plate warmer before the fire reflects the heat upon the plates. This is a great cause of the warmth of this favoured district, and of the lovely semi-tropical vegetations which there abounds.

Another important fact is the proximity of the land-locked Mediteranean Sea. In this sea are no Polar currents, although there is doubtless some circulation and some warm surface currents blown from its southern shores. The deep sea temperature of the Mediteranean is over 50° Fahr., while that of the Atlantic outside the Straits of Gibraltar is only 36° Fahr. In this spot several of those conditions which conduce to a warm temperature come together, and its popularity with physicians and the public is not to be wondered at.

There is no such thing as a climate which any of us would ignorantly and selfishly call perfect. Even the favoured Riviera has its drawbacks, and the staple of conversation among the more delicate of the frequenters of this part of the French coast is the "mistral," the north-west wind, dry, cold, and boisterous, which, after traversing the centre of France, forces its way through the gorges and round the spurs of the Alpes Maritimes, and sweeps rudely into the sacred warming pan which lies between Toulon and San Remo. When the mistral blows, the sky is clear and bright, the air is dry and crisp, and, if escape can be found from the clouds of dust which it raises, it is stimulating, and not unpleasant to a man in good health, who is able to move about and warm himself by exercise. The mistral is most intolerable in a town, where it sweeps down the streets and round the corners with a fury positively dangerous to feeble people, and accompanied by clouds of dust which must be not bad imitations of the dust storms of the desert. The mistral is very chilling, and very irritating to persons with weak lungs, and the only thing for invalids to do while it is blowing is to sit indoors, and if they have sunny windows facing the south-east, they will much enjoy the bright sky and warmth, and will not feel the wind.

The mistral, as I have previously hinted, is probably one of the best friends of this coast. It must be the most potent scavenger, drying up filth, holding putrefaction in check, and purging many a foul corner of its dangerous accumulations. Another drawback to the Riviera is the wide range of temperature, which is a snare to the unwary. Between sunshine and shade there is often a difference of 73° Fahr., and between midday and midnight the difference is equally great. Insufficient clothing, and careless exposure after sunset or to night air, has cost many an invalid his life.

The extremes of temperature which may be encountered on the globe are very remarkable. The average temperature for the month of May at Massowah, in the Red Sea, is (according to Scott) 99° Fahr., while the winter average for Werchojansk, in Siberia, is—56 Fahr. There is, therefore, a range of 155 degrees between the hottest month at Massowah and the coldest month in the heart of Siberia.

Sir John Herschel has recorded a temperature of 159° Fahr., observed on sandy soil at the Cape of Good Hope, and the lowest actually recorded temperature is —81° observed by Gorochow, in Siberia. As to the endurability of these extremes, Scott quotes Dr. Moss, who, in his "Stories of the Polar Sea," says:—

"Many a time the relative merits of Arctic cold and tropical heat were warmly canvassed. Many of our officers and men had lately returned from the Ashantee campaign, and they could speak with authority. There was one thing clear, one could sometimes get warm in the Arctic, but never cool on the coast."

Nothing is more calculated to rouse our

admiration and amazement than the manner in which the animal body accommodates itself to extremes of temperature. Men will go from tropics to Pole and from Pole to tropics, and maintain a fair level of health at both, and we may well pause to inquire how this is managed.

Life in the tropics is a simple matter. There is no necessity for clothing or firing, and a handful of dates will almost supply the food wants of the individual. Protection from wild animals and from fellow men is almost the only thing necessary to preserve life.

A naked animal like man could hardly move far from the tropics until he had learnt a little tailoring, and had found out how to turn the skins of the lower animals to his own account. The art of building huts or tents would enable him to move still further north, but without the great discovery of fire he could hardly have penetrated into cold climates, and still less could he maintain an existence there. The great trouble in the Arctic regions is to keep up the animal heat, and this is only to be done—(1) by the adoption of every kind of artificial protection against cold, and (2) by the supply of sufficient food, which is often no easy matter. Food in abundance is most important, as without it the temperature of the body cannot be maintained. The Esquimaux will consume ten pounds of animal food per diem. Food is the fuel which we put into the internal furnaces of our bodies. In a week or two the lambing season will begin, and many of us will wonder how the delicate younglings manage to support so much cold and exposure; but the farmer will tell us that, provided there be food enough for his ewes, and, by consequence, milk enough for the lambs, he has no fear of snow and cold, at least in moderation.

One advantage of an Arctic climate is the total suppression of putrefaction, and the inability of animal and vegetable parasites to get a hold of our bodies.

The effects of temperature *per se* upon the animal body are very difficult to determine, as it is almost impossible to separate temperature from other conditions which follow in the wake of, or accompany, extremes of temperature.

If the temperature of the blood be raised higher than 113° Fahr., life is scarcely possible, because at that temperature myosin coagulates and the muscles become rigid. Although in the tropics the direct rays of the sun may raise objects upon which they fall to a temperature not far short of that of boiling water, yet the blood temperature is not raised to any great extent above normal (98°·4 C.) so delicate is the machinery for regulating the temperature of the animal body. When the temperature of the body is raised, it is probable that the conducting power of the nerves is lowered, and this again is a source of danger to life. When the direct rays of the sun fall upon the head and the nape of the neck, it occasionally happens that the heat-regulating machine of the body is paralysed, and then we get what is known as sunstroke or heat apoplexy. The same accident may occur in the shade when the temperature of the air is high. It is a great question whether high temperature *per se* is sufficient to produce heat apoplexy or sunstroke. This accident has often been associated with conditions which induce foulness of the air as well as heat, and Dr. Parker points out that sunstroke and heat apoplexy are very rare at sea, or on mountain heights, notwithstanding that the effect of the sun's rays is very intense in these situations. Very often clothing and dirt seem to have conspired to render the victim intolerant of heat, and unable to regulate the temperature of his body.

There is some evidence to show that when an inhabitant of a temperate climate voyages to the tropics, there is slight elevation of body temperature which, however, at the most is less than 2° Fahr. After a short time the increased action of the skin equalises the temperature, which is maintained at about 99° Fahr., a heat which appears to be that which is most favourable for the performance of vital functions. Dr. Rattray has shown that the respirations in the tropics become slower and somewhat deeper, and that the respiratory function is lowered to the extent of about 18 per cent., so that if a man gets rid of ten ounces of carbon by the lungs in a temperate climate, he will only eliminate a little more than eight ounces in the tropics.

Parkes and Francis have both noticed that the lungs of Europeans dying in the tropics become lighter and weigh less than the normal *post-mortem*. Not only is the respiratory function lessened, but the amount of oxygen per cubic foot of air is lessened also, as we have seen. This lowered respiratory function must have the effect of lessening heat production.

Heat increases the action of the skin, but is said to lessen the activity of the heart and kidneys, to lessen the digestive power, and to lower the nervous energy of the body. Rattray's observations on naval cadets show that in the tropics the increase of height was considerable,

but notwithstanding this, most of the lads under observation (48 in number) lost weight.

Cold.—How little effect mere cold has upon the health is shown by the interesting but trying experiences of the crew of the *Eira*, the yacht which was fitted out by Mr. Leigh Smith for the purposes of Arctic exploration in the year 1881. The *Eira*, it will be remembered, left Peterhead on June 14th, 1881. When she had reached Cape Flora, in Franz Josef Land, a point near the 80th parallel of north latitude, the yacht was nipped in the ice pack, and quickly sank. The crew and a good deal of the cargo were got on shore. The account given by Dr. W. H. Neale, the medical officer of the expedition, is full of interest. This gentleman says, in a communication to the *Lancet* in August, 1882:—

"I am afraid there is very little to say, in a medical point of view, with regard to the late Arctic expedition of Mr. Leigh Smith, its great characteristic being the singular absence of disease among a crew of twenty-five men, during a sojourn of fifteen months in the Arctic Regions."

Two men who were invalids before they started, and who ought not to have been allowed to join the expedition, remained ill the whole time, and returned home invalided, but beyond this, there was no sickness worth speaking of.

A considerable quantity of preserved provisions was saved from the wreck, together with tea, tobacco, and rum, and, luckily, some firearms and ammunition were also saved, so that there was no lack of fresh meat, chiefly walrus and bear. There was no lack of food. They were able to have, collectively, from 25 to 50 lbs. of fresh meat every day, together with 12 lbs. of tinned vegetables, tea night and morning, one ounce of rum, and a quarter of a pound of flour made into a "dough-boy." Thus there was no question of scanty rations. The meat was made into soup, and to the soup some of the blood of the animal was added, and this, it is said, greatly improved its quality. If, however, the dietary was passable and endurable, what were the other conditions? A hut was built of stone and turf, 38 ft. by 12 ft., and with an average height of 5½ ft. This was divided into three compartments by canvas partitions. One of these, containing about 1,250 cubic feet of space, served as the forecastle, and here twenty men slept with a little more than 60 cubic feet of space each.

The middle compartment, containing about 660 cubic feet of space served as the kitchen, and the third compartment, with about 594 cubic feet, served as a store-room for provisions, &c., and as the sleeping apartment for Mr. Leigh Smith, Dr. Neale, the ice master, and the two invalids. In planning the hut, the ventilation had been carefully considered. The doorway opened into the middle compartment, and was approached by a long porch (seventeen feet long), and opposite the door was the kitchen fire. A sail served as a door, and through this door there came a free current of air, and ventilation was further provided for by putting some old meat tins through the roof, the lids being put on or taken off the tins at pleasure, and according as the weather and snow permitted. Notwithstanding that the ventilation had been so wisely provided for, it is evident, considering the small cubic space per man, and the excessive coldness of the incoming air, that the supply of fresh air must have been almost incredibly small. The temperature of the outside air was −43° Fahr., and often lower than this for hours together. Sixty-five degrees of frost! We are told that a temperature of 20° Fahr. was considered warm in the captain's sleeping apartment, and that the thermometer often stood at zero Fahrenheit on the ground in the kitchen.

"Our clothing," continues the narrative of Dr. Neale, "was scanty, consisting of woollen and flannel garments; no skins or furs of any kind were worn, and I do not think they are necessary, unless one is sledging, or obliged to go out in all weathers to make observations." For ten long months these men led this life, enduring the intense cold and the prolonged darkness. At the end of it they bore the hard work of a six weeks' journey across the ice, and were ultimately picked up by Sir Allen Young, all sound and well.

There was no trace of scurvy to be found in any of the crew, a fact attributable to the daily supply of fresh meat. One man had an attack of bronchitis and pleurisy, which kept him to the house for three weeks, and another was ill from bronchitis for a fortnight. This was the sum total of lung disease, and, be it observed, recovery took place at least as rapidly, if not more so, than usually is the case in London. There were slight cases of frost-bite, easily cured, but no severe cases. There was some trouble with the digestive organs at first, but when the men got accustomed to their novel diet, this at once subsided. When the sun appeared in the spring, snow blindness was troublesome. In short, when they were picked up by Sir Allen Young, they were all well and ruddy, and Dr. Neale notices it as worthy of

remark, that the almost total lack of light in the winter had no effect in producing pallor.

It is also a remarkable fact that, although washing was impossible for weeks together, there was no appearance of vermin upon the heads or bodies of any of them, a fact which seems to show that a temperature of minus forty-three is not favourable for parasites.

I had the pleasure of meeting Dr. Neale, within a few days of his return to London, and he looked, as one would say, "the picture of health," ruddy, and plump.

This interesting narrative shows that the extremes of cold and darkness do not necessarily of themselves endanger life.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The number of visitors to the Exhibition for the week ending Tuesday, 23th inst., was 167,937. Total since the opening, 1,153,630.

TRADE WITH THE RED SEA PORTS.

The *Marina e Commercio*, published at Rome, gives the following particulars respecting the trade at the Red Sea ports, for the information of merchants and manufacturers in Italy who may be desirous of establishing commercial relations there.

Suakin is a city of 5,000 inhabitants, with a large and good harbour. The cost of carriage of merchandise from the anchorage to the shore is one dollar per seventeen packages, or, if the warehouse is situated some distance from the sea, then the same price is charged for only nine packages. The goods for exportation are usually packed in matting; gum and coffee in sacks. The trade with the interior is chiefly in the hands of native merchants. The principal articles of importation are ready-made clothes; both cotton and woollen are imported, and sent to Khartoum and other towns in the interior. Light cotton stuff for turbans, the greater part of which is manufactured at Manchester, are imported in considerable quantities. "Fez" are chiefly made in Austria, and are, in some cities, imported direct from that country, and in others, from Alexandria; they are purchased principally for the Egyptian troops. Shoes are imported from Vienna. Iron and steel, shipped from London or Liverpool, form a considerable branch of trade in the Soudan. Nails (*points de Paris*) come principally from Marseilles. Furniture, chiefly chairs from Vienna, are sent to Khartoum and Kassala. Candles in packets of eight, weighing 466 grammes, are supplied from Marseilles, and cost one franc per packet. The lucifer matches are chiefly of the ordinary kinds, with sulphur, and come from Alexandria. Soap is principally imported from Syria, but that of Italian make, and from Pontelagoscuro, is gradually finding its way into the market. Austria supplies the glass and crockery ware. Letter paper from Fiume, cigarette paper from Austria, whilst paper for packing comes from Alexandria. Spirits of wine is supplied by Hungary, and is used chiefly for making a liqueur called *Mastique*. Only the inferior sorts, cognac, vermouth, absinthe, and bitters, find a sale at Suakin. Double refined sugar, in the loaf, comes from Marseilles, whilst the ordinary or inferior qualities are imported from India. A small quantity of rice, macaroni and potatoes are imported from Trieste. The exports from Suakin are limited to raw products, gum arabic being the principal, a large quantity of which is brought from Khartoum and Kassala, and is shipped by Egyptian steamers to Suez, where it is taken by other vessels to Trieste and London. A considerable saving might be made were it shipped direct for Europe. The next product in importance is that of mother of pearl, which is exported principally to England and Trieste.

Calves' hides are exported chiefly to Salonica; these hides are untanned, and merely salted and dried in the sun. Abyssinian coffee is principally sent to Dieddah and Upper Egypt, it is not, however of first-rate quality, but, at the same time, it has a special aroma; it is sold at 16 dollars per cantaro of 113 rottoli. A small quantity of wax is brought from Gedaref, and is shipped at Suakin for Trieste or Genoa.

Ostrich feathers are brought from Khartoum, and are shipped to London. Ivory is exported principally to Bombay; tamarinds to Lower Egypt; and the gutta-percha of Kassala to London.

At Massaua the most important articles of importation are cotton goods (shirting, &c.) from Manchester. Red cotton twist of English manufacture is in considerable demand at Massaua, as well as another quality of cotton fabric, also of English make, called in Arabic *juta;* it is worn by the Abyssinians as a kind of apron, and is usually a red and white check, or white with a red border. Printed calicoes are brought principally from India, and are largely used in Abyssinia for female dress; a light cotton fabric of English make is also used for the same purpose. Cotton goods form the principal staple of export to Abyssinia, and the merchants of Massaua either order them direct from England or through agents at Alexandria.

Cloth is chiefly brought from Bombay, but in small quantities. Silk stuffs are also imported in small

quantities from Milan, Monza, and England, and are used for dress by the rich Arabs.

Glass ware is chiefly in the hands of Greek traders, who import it from Alexandria. The Abyssinians buy a small quantity of drinking glasses and small bottles of a special shape for containing a beverage called "Tecc," made from honey. Earthenware is imported in small quantities. Common soap with label printed in Arabic is brought from Alexandria, and is principally used by the inhabitants, and sells at a dollar per 3½ kilogrammes.

The cheap kinds of lucifer matches from Alexandria are sold principally at Massaua, the better qualities from Austria being less in demand. Candles of an inferior quality from Marseilles, in packets of eight, weighing 460 grammes, sell at 1·12 francs per packet. Venetian beads are imported in considerable quantities for the Abyssinian market, and to the extent of 50,000 francs annually.

The loaf sugar used at this town is brought principally from Marseilles; the Austrian sugar, however, would find a market here, if the loaves did not exceed three kilogrammes in weight. Indian rice is imported in large quantities, notwithstanding that the trade with Abyssinia is comparatively small.

Spirits are imported in considerable quantities from Trieste by the Greek traders, and is used by the Abyssinians for preparing liqueurs. Large quantities of inferior liqueurs are imported from Marseilles—a bottle of absinthe costing one franc. The annual consumption of Vienna beer at Massaua is about 12,000 bottles.

The principal articles of export are gum arabic, calves' hides, brought chiefly from Abyssinia, and a small number from Galabat. They are shipped to Salonica, Trieste, Leghorn, Genoa, and Venice, and cost 24 dollars per package of twenty skins. Ivory is brought exclusively from Abyssinia, and is shipped to Bombay; the price is about 200 dollars per cantaro of 200 rottoli. Mother of pearl is sent principally to Austria. Leopard skins, numbering about 1,000 annually, from Abyssinia, are sent to India, and cost on the average three dollars per skin. Abyssinia furnishes musk, which is contained in bulls' horns, about 200 to 300 of which are exported every year to Alexandria and Bombay.

Abyssinian butter is met with at all the ports on the Red Sea, but on account of the excessive heat it is in a melted state, and is not a wholesome or tempting article of food. It fetches from 3½ to 4 dollars per *madhana*. From 50 to 60 head of cattle are exported monthly, selling at 7 to 8 dollars per head, averaging from 130 to 140 kilogrammes each. Honey is also an important article of export from Abyssinia; the wax, chiefly from Galabat, is exported to Genoa and Leghorn. The value of the peals exported annually amounts to lire 250,000 to 300,000. Finally, the tobacco grown at Sanaaid is exported principally to Egypt to the extent of 100,000 oka annually. The much finer of this tobacco in the leaf is 4 piastres per oka.

RICE IN MEXICO.

The United States Consul at Manyanillo says that the State of Colima is the principal rice-producing State of the Mexican Republic, having produced during the year 1883, over 4,000,000 lbs., and this production is steadily on the increase. The adjoining State of Jalisco produced, during the same period, over 2,500,000 lbs., and Michoacan about 2,000,000 lbs. The method employed in the production of rice is as follows:—The field suitable for the cultivation is ploughed in July, and the seed rice is sown broadcast over the field, by hand, and then cross ploughed. The irrigation water is allowed to overrun the entire ground as soon as the young shoots are from three to four inches high, and the field is left under running water until the plant has attained a height of about two feet, which is in about a month or six weeks. The young plant and weeds are then cut, by hand, down to a height of about three inches from the ground, with a curved implement called *guadana*, and during this time the water is dammed up and the field is dry. The cut-off portions of the plant, and weeds, are left on the ground to rot; the field is again put under running water, after which, the rice growing rapidly, it is left to itself until the time of harvest, in November or December, when the cutting commences, with a species of sickle called the *rasadera*. The farm labourer is provided, in addition to the *rasadera*, with a common straw or rush mat, about two feet square, which he spreads on the ground, and upon which, having cut as large a bundle as he can hold in one hand, he strikes the ears a couple of times for the ripe grain to fall out on the mat. When this mat is covered with the grain, it is taken up, and the grain emptied into sacks which are brought to an open platform near the houses of the *hacienda*, made up of a kind of cement or hydraulic mortar, upon which the unshelled rice is spread out and exposed to the sun to dry. When dry, it is again put into sacks, and stowed until the proper time for hulling has arrived. The hulling and cleaning of the rice is performed in the following primitive manner. Under a shed, or in the *hacienda*, are placed at intervals of about three feet, in single or double rows, from ten to fifty round wooden trunks cut from the stems of good sized trees, about two feet and a half high by two feet in diameter, firmly set into the ground. In the centre of each trunk is carved out an inverted cone-shaped hole, upper diameter about ten inches, and twelve to fifteen inches deep. In this hole is placed some unhulled rice to within about one inch of the top, and a labourer, with a heavy wooden mallet in his hands, hulls the rice by pounding it for a considerable time. The rice, together with the loose husks, is then taken out and put in baskets. The hole is refilled with unshelled rice, and the laborious hulling goes on from day to day and week to week. The rice is cleaned or separated by lifting the baskets up in the

air above the head, and letting it slowly fall upon a mat, whereby the light husks are carried off by the wind. This operation is repeated once or twice if necessary. The rice is then put into sacks of about 175 lbs. each, and is ready for market. Occasionally, instead of single trunks or mortars being placed separately in the ground, there is used a long, heavy, square log of about two feet square, and thirty to forty feet long, with a number of holes carved out at certain intervals.

PROPOSED BERLIN MUSEUM OF COMMERCE.

Consul Potter, in his last report on trade and industries of Germany, states that an idea has recently taken practical form in Berlin, through an organised association of gentlemen, who propose to establish with Government aid an "Imperial Museum of Commerce" in the City of Berlin. After this institute is placed upon a sound basis, it is proposed to establish branches in other great centres of trade in Germany, with a view to collecting information concerning commerce and the various industries of the country, also concerning production, consumption, and condition of the markets in foreign countries, and any other information that may be advantageously used in promoting commerce and trade, and the various industrial and manufacturing interests in Germany. It appears that an executive committee has been chosen to confer with the Minister of Commerce with a view to selecting a suitable building in which to receive and arrange the collections for convenient exhibition, and for the offices of the managers of the museum, and also for the purpose of petitioning the Imperial Government to instruct its consular officers throughout the world to purchase specimens of such articles and products as can be manufactured and furnished by Germany, or which can be used as raw material for manufacturing purposes, and to furnish full particulars concerning such articles. The Executive Committee of the proposed Imperial Museum of Commerce have been instructed to negotiate with the Prussian Minister of Public Works, who has established in Berlin an official bureau of information concerning railways and railway tariffs, and the Prussian Minister of Commerce, who has decided to establish a bureau of information concerning customs duties, with a view to connecting the Imperial Museum of Commerce with the two bureaus having in charge matters relating to railways and eustoms duties. The committee have also been instructed to confer with the proper authorities in important trade centres who may desire to have established in their district a branch of the commercial museum, and to frame rules which shall govern the relations of such branch establishments to the chief office at Berlin. The committee is authorised to issue a public call for voluntary contributions from the commercial and industrial classes throughout Germany, and later on to apply to the Imperial Government to make good any deficiency which may be necessary to perfect the proposed institution. Consul Potter says that the value of such an institution cannot be over estimated, as the business community could there obtain full and trustworthy information concerning the particular needs and requirements of people in all parts of the world, and specimens of goods that are popular among them could be seen and examined, and fresh information relating to the condition of markets, customs duties, railway tariffs, and the cost by other means of transportation could be easily and quickly obtained.

THE PREPARATION OF DRIED MEAT AT MONTEVIDEO.

The Italian Chamber of Commerce at Montevideo has forwarded to the Minister of Agriculture at Rome a sample of dried meat called "tasajo," largely used in South America, with a view to its introduction to the Italian markets. This sample has been divided and sent to the chambers of commerce of Genoa, Turin, Milan, Venice, Florence, Rome, Naples, and Palermo.

The "tasajo" is made usually from the meat of young bulls from three to five years old, and sometimes from that of bullocks and cows. It is prepared in the following manner.

The meat of the animals just slaughtered, and whilst still warm, is cut up and hung till cold in spacious and well ventilated chambers, and then it is ready for the process called "charquear," consisting in opening and cutting up into slices, the thickness of which varies according to the season and upon the market for which the "tasajo" is intended. The meat thus prepared is next salted, and put into brine for three or four days, and turned daily; it is next washed in fresh brine, and hung to dry in the sun during the day and taken in at night, and when perfectly dry is subjected to considerable pressure in a press, and exposed to the sun every other day from four to ten times, after which, being perfectly desiccated, it is fit for exportation.

The greatest attention during the process is paid to cleanliness, a matter extremely necessary when carried on on a large scale, and when from 400 to 500 animals are slaughtered daily, and in some establishments the meat from 1,000 to 1,200 head of cattle is treated every day.

Before using this meat, it is necessary to remove the salt, which may be done by steeping it in cold water and allowing it to soak for twelve hours; or more rapidly, by putting it into hot water for a short time, and rubbing it well in order to remove the coating of salt, and then washing it in cold water. The nutritious qualities of the "tasajo" are said to be equal to those of fresh meat. The price at Montevideo, free on board, including packing, varies from 20 fr. to 25 fr. per quintal (about 2 cwt.), and the freight to Italian ports does not exceed 20 fr. per ton.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society's Conversazione was held, by the kind permission of the Executive Council of the International Inventions Exhibition, in the Exhibition buildings, South Kensington, on Friday evening, the 3rd of July.

The reception was held near the principal entrance to the Exhibition in Exhibition-road, by Sir Frederick Abel, C.B., D.C.L., F.R.S. (Chairman), and the following members of the Council:—Mr. E. Birkbeck, M.P., Mr. Alfred Carpmael, Mr. Andrew Cassels, Mr. Brudenell Carter, Mr. E. Chadwick, C.B., Mr. Charles Cheston, Lord Alfred S. Churchill, Mr. B. Francis Cobb, Mr. T. R. Crampton, Sir Villiers Lister, K.C.M.G., Mr. J. M. Maclean, Mr. W. G. Pedder, Mr. W. H. Preece, F.R.S., Sir Robert Rawlinson, C.B., Mr. Owen Roberts, and Mr. R. E. Webster, Q.C. M.P., (Attorney-General).

Several illuminations of the fountains took place during the evening, for which special features were arranged by the kindness of Colonel Sir Francis Bolton.

The band of the Grenadier Guards, conducted by Mr. Dan Godfrey, performed in the Western Kiosk, and the Strauss Orchestra, conducted by Herr Eduard Strauss, in the Eastern Kiosk. The band of the Pomeranian (Blücher) Hussars, conducted by Herr Karlipp, performed in the gardens adjoining the Austrian Court. The court band of H.M. the King of Siam performed in the conservatory.

A concert was given in the Music-room, from 9.30 to 10.30. Mr. Oscar Beringer, pianist, and Miss Thekla Friedlaender, and Miss Franziska Goldstein, vocalists; pianoforte by Messrs. John Broadwood and Sons; also from 10.45 to 11.45, pianoforte and violin recital by the Misses Agnes and Violet Molyneux; pianoforte by Messrs. J. and J. Hopkinson.

Pianoforte and organ recitals were given in the Central Gallery during the evening; from 9 to 9.30, by Mr. E. H. Sugg, on Messrs. Henry Jones and Sons' organ; from 9.45 to 10.15, by Mr. Ernst Wertheim, on Rudolf Ibach Sohns' grand pianoforte; 10.30 to 11.15, by Madame Roger-Miclos, on Messrs. Pleyel, Wolff and Co.'s pianoforte; and from 11.15 to 11.45, by Mr. W. S. Hoyte, on Messrs. J. W. Walker and Sons' organ. A pianoforte recital was also given in the Russian Court, by Mr. J. C. Barnett, on Messrs. Eavestaff and Sons' pianoforte. An organ recital was given by Mr. Hoby during the evening in the South Gallery, on Messrs. Bryceson's electric organ.

The number of visitors present at the Conversazione was 10,652.

Proceedings of the Society.

CANTOR LECTURES.

CLIMATE IN ITS RELATION TO HEALTH.

By G. V. Poore, M.D.

Lecture II.—Delivered January 19th, 1885.

The Floating Matter in the Air.

It is a well-known and universally acknowledged fact that different climates are inhabited by different animals and plants. It is also well known that animals and plants, which are indigenous to tropical and warm climates, quickly die in colder regions, unless artificially protected. In Polar regions vegetation becomes exceedingly scanty, although the Polar seas teem with life. Animal life is more easily supported in cold countries than is vegetable life. Man, as we have seen, is able to encounter for months the very extremities of cold without any detriment to his general health, but he is enabled to do so only by artificial help from clothing and firing, by building a warm hut for shelter, and by packing close into this hut for the sake of mutual warmth. The conditions under which the crew of the *Eira* enjoyed such rude health in Franz Josef

Land, conditions of which overcrowding and dirt were the chief characteristics, would be stigmatised in this or any temperate climate as most unhealthy, and such as would certainly quickly prove highly prejudicial, and in all probability cause sore throats, lung disease, consumption, and other troubles.

Such conditions of life in the tropics would be scarcely less fatal, probably, than was the Black Hole of Calcutta. Why is it that conditions of life which would be fatal in the tropics are apparently harmless at the Pole?

The only explanation which I am able to offer is this, that at the Pole, putrefaction, decomposition, and decay of effete matters is, owing to the low temperature, impossible. What we call dead organic matter becomes a prey to lower forms of life, both animal and vegetable; but in the Polar regions these lower forms of life, if existent, are unable to manifest any vitality, and those processes, of which putrefaction is the type, are in abeyance.

The extreme cold and the extreme dryness of Polar regions are both opposed to anything like putrefactive change; and it is a remarkable fact that among the Eskimo (who absolutely never wash, who inhabit their clothes almost as continuously as they do their skins, and who live in a state of filth without its parallel in the world) filth disease should be conspicuous by its absence. If cold and dryness check putrefaction, warmth and moisture equally encourage it, and in tropical climates (unless the dryness of the air is very great), putrefaction runs riot, and diseases dependent upon the decay of organic matter run riot also. Up to this point we seem to have arrived at certain conditions:—

1. That the varying chemical constitution of the atmosphere has no great effect upon health.

2. That the amount of moisture in the air may vary considerably, and by so doing may cause a certain amount of comfort or discomfort to invalids, but that the humidity of the air has no great effect upon health, except in so far as it effects the processes connected with putrefaction and decay.

3. That the extremes of heat and cold *per se* can be borne by healthy men under favourable circumstances without any very serious results; but that a high temperature is indirectly dangerous, because of the facilities which it offers, so to say, to all putrefactive changes.

As far as we have gone, we seem to be landed in the conclusion that none of the atmospheric conditions we have considered are of necessity directly harmful to the individual; but that, indirectly, those conditions which favour putrefactive and allied changes may be very prejudicial to his health.

A glance at two of the diagrams suspended from the screen will serve to show you that there is a most unmistakable connection between the temperature of the air and the death-rate from two classes of disease.

The first shows that the deaths from diseases of the respiratory organs rises as the temperature falls; or, in other words, that in cold weather, death from lung disease reaches its maximum. We must not conclude from this that cold, *per se*, is the great cause of lung disease, for I shall probaby convince you, before these lectures are finished, that overcrowding, intemperance, starvation, and a sewage-sodden soil, are more active causes of this form of disease than cold.

To persons whose lungs are already diseased, cold is very trying, and the extremes of cold kill off, as it were, the sufferers from lung disease more than they cause the disease itself. Again, old people are liable to suffer from inflammation and congestion of the lungs; and in fact, this is one of the recognised ways in which death comes to the aged, so that many of the deaths registered in very cold weather as deaths from lung disease, are, in reality, those of very old people, and others whose debt of nature was due, or over due.

The other diagram shows that during periods of high temperature the mortality is high from diarrhœa. The cause of this diarrhœa is probably to be found in the facilities afforded by high temperature for putrefactive change. In warm weather, as we know, milk "turns," meat goes putrid, fruit gets rotten, and all collections of putrescible matter are more than usually offensive to the nose. The sewer gratings smell, and the kitchen sink is malodorous in warm weather; and it is in warm weather especially that we write to *The Times* to complain of the filthy condition of our Father Thames. The consumption of putrid food, and the inhalation of putrid air, are both acknowledged causes of diarrhœa; and it is probably *viâ* putridity, so to say, that summer raises the death-rate from diarrhœal diseases.

As we advance into the tropics, speaking generally, the amount of disease increases; and if we look at Keith Johnston's map of the "Geographical Distribution of Disease" we find that the chief diseases are—

1. Malarious diseases (fever, ague, and dysentery).

2. Yellow fever.

3. Cholera.
4. Typhoid, and allied forms of fever.
5. Ophthalmia.

Now each of these diseases I have named is certainly connected with putrefactive and allied conditions. Malaria is caused by decay of organic matter in marshes and similar places. Yellow fever is a disease mainly of the cities of the western tropics, and is certainly mainly dependent on the putrefaction of fæcal and other animal matters. Of cholera it may safely be said that fæcal discharges are one medium for its propagation, and that it gets its strongest hold where putrefying filth is allowed to pollute the soil and air. Typhoid is a recognised filth disease; and ophthalmia, which is the scourge of Egypt, and other Mediterranean stations, has been clearly shown, in more than one instance, to depend on air fouled by fæcal decompositions.

Here, then, we find that an enormous proportion of tropical disease, if not wholly dependent on, is in some way inseparably connected with, the putrefaction and decay of organic matter, whether vegetable or animal.

Undoubtedly, one of the greatest scientific advances which has been made in the present day was made by Pasteur, when he demonstrated that fermentation and putrefaction were due to the growth of low forms of vegetable life at the expense of the fermentable or putrescible liquid; and that if the aforesaid vegetable organisms can be excluded from the fermentable or putrescible matter, then neither fermentation or putrefaction will take place, and the fluid will remain unaltered, even for years.

Unless special precautions be taken, any putrescible fluid, if left to itself, will putrefy. How is this brought about? The answer is, that the active agent of the putrescible change is supplied by the surrounding media. The soil, the water, a neighbouring putrefactive focus of some kind, supplies the necessary organism; this is wafted through the air, and sets putrefaction agoing in the putrescible fluid.

Apart from all other considerations, this undesirable sequence of air-borne germs, putrefaction disease, is enough to invest with the deepest interest the question of the floating matter in the air, to which we shall now, for a short time, turn our attention.

A London audience, I feel, is not unlikely to have some sort of prejudice in favour of the proposition that floating matter does exist in the air, and that in no small amount.

As to the nature of the matter which may be found floating in the air, the variety is infinite, and the distance which floating matter may be carried by the air is also very variable. Thus I have the authority of Mr. Buchan, the author of the article, "Meteorology," in the "Encyclopædia Britannica," for stating that "The tornado which passed over Mount Carmel (Illinois), June 4th, 1877, swept off the spire, vane, and gilded ball of the Methodist church, and carried it bodily fifteen miles to the north-eastward."

Again, whirlwinds occasionally raise the fine sand of African deserts high into the atmosphere, whence it is wafted distances which seem incredible, and has been known to fall upon the sails of ships 600 or 800 miles away; and in the city of Berlin have been found organisms which, according to the learned, must have had their origin in African deserts.

The fact that comparatively large and appreciably ponderable particles can be carried such long distances through the air, will prepare the mind to accept without difficulty the proposition that particles so attenuated as almost to elude the grasp of the mind's eye may be transported any distance.

This important question of the solid matter in the air has, for some years past, been attracting an increasing amount of attention. The dust which is deposited in sheltered places comes from the air, and many microscopical examinations and chemical analyses of dust have been made. The dust of Dublin was found by Tichborne to contain from 29 to 45 per cent. of organic matter, which was chiefly composed of finely ground horse droppings; and among the unpleasant things which have been found in dust may be mentioned:—Scales from the human body, the dried matter from suppurating wounds, the insects which produce the disease called itch, the fungus which causes ringworm, and scales from small-pox pustules.

Reading such a list as this we cannot help feeling that the potentiality for evil of dust and dirt may be very great, and the natural reflection will force itself upon us, "Do these things, and such as these, become dried, and then, lifted by the wind, and carried through the air, work mischief at a distance from their source of origin?" The floating matters in the air are mineral, vegetable, and animal. If air be directed through a suitable apparatus, the details of which I need not trouble you with, the solid particles will

be deposited, and may be examined with the microscope. In dust collected in this way microscopists have recognised a variety of things, and Ehrenberg has recorded over 200 of the lowest forms of life thus floating in the air. Blackley was one of the first to direct attention to the enormous amount of pollen (the fertilising dust of flowers) to be found in the air, even at considerable elevations, and Maddox has specially directed attention to the innumerable spores (the reproductive seeds) of different forms of fungi.

The evidence of the richness of the air in spores of fungi is before us every day, for if we leave any moist organic matter exposed to the air, we find it "mouldy" after a lapse of a few hours. These "moulds" are in great variety, and differ considerably in colour and "habit," as a gardener would say. Whence came they? The most probable answer is that the spore, or seed, was deposited from the air upon the organic matter, which served as a suitable soil, where the spore quickly reproduced its kind to ripen and give off, in its turn, its thousands or millions of spores to every passing breeze.

The systematic examination of the air is now being carried out in many laboratories, but nowhere more systematically and thoroughly than at the observatory of Mont Souris, in Paris. The work of this observatory is, to some extent, of a novel character, so that I think I shall not do wrong in giving you a sketch of it.

The observatory is under the care of the municipality of Paris, and is situate in the park of Mont Souris, in the extreme south of the city, just within the fortifications. The observatory is under the direction of M. Marié Davey, and its work is divided into three sections, viz.:—

1. Meteorology proper, including magnetic and electrical observations.

2. The chemical analysis of air and rain.

3. The microscopical study of the organic matter suspended in the air, or in the rain and other water collected at the observatory. This department is under the control of M. P. Miquel.

At the close of every year the observatory issues the "Annuaire de Mont Souris," a book full of information, and from which, as well as from Miquel's "Organismes Vivants de l'Atmosphère," much that I am going to say has been derived.

Dr. Miquel has, with regard to the air, made two series of observations, one having reference to the forms of moulds, fungi, and other lowly organisms, as well as inorganic matter, and the other with reference solely to bacteria and micro-organisms closely allied to them.

Pasteur seems to have been the first to call the attention of the scientific world to the importance of studying the organic matters wafted by the air, and, in 1862, he published a memoir on the subject in the "Annales de Chimie et de Physique." For the next eight years, work in this direction was not very active; but, in 1870, Dr. R. L. Maddox published in the *Monthly Microscopical Journal* the results of a series of experiments made by him with the object of determining the relationship between the organic germs of the atmoshere, and the other meteorological conditions. The main facts established by Dr. Maddox were as follows:—

1. The immense variations which occur in the number of spores floating in the air, variations the extremes of which are represented by the numbers 1 and 250.

2. The small influence which, in the open country, the direction of the wind has upon the number of spores.

3. Their increase in summer, especially (in England) July and August.

4. The velocity of the wind has no constant relation to the number of spores.

5. In very windy weather the inorganic sediments are increased, but there is no increase of spores.

6. Wet weather seems to have the effect of fixing the mineral matters in the soil, but has no similar effect on the spores.

Dr. Maddox found that the spores collected from the air belonged to every form of fungus, and to many forms of lichen. Further, he found portions of green algæ, and a great variety of pollen. Further, Dr. Maddox succeeded in cultivating in suitable liquids many of the spores which he collected.

It was not till 1876 that the systematic observations of air-borne spores was commenced at Mont Souris by Dr. Miquel.

Taking the average of the four years, 1879-82, Dr. Miquel found that each litre of air contained from 12 to 15 spores, and that, in general, they were slightly more abundant during hot years. The effects of season were well marked. Thus in winter there were 6·6 spores per litre of air; in spring, 16·7; in summer, 22·8; in autumn, 10·8.

By means of a most ingenious registering aeroscope, Dr. Miquel has been enabled to observe the hourly fluctuations in the number

of spores. This fluctation is very great indeed, and the causes of it are not always apparent. One fact seems to come out clearly, viz., that a fall of rain has the effect of partially clearing the air of spores for a time.

The causes of the hourly fluctuation are, according to Miquel, mainly two, viz., remote and local. Let us imagine a mass of air travelling from north to south. Coming from regions of ice, and orginally very pure, it strikes a continent, and the mass of air which impinges on the soil makes almost a clean sweep of floating spores, and largely enriches itself at the expense, as it were, of the masses of air following in its wake. Thus the richness in spores diminishes as long as the air blows strictly from one direction.

Among local causes of variation may be mentioned the neighbourhood of great towns or other centres of spore productions.

By means of the registering aeroscope, Miquel has been able to estimate the amount of mineral matters in the air. When the wind blows from the north (*i.e.*, over the City of Paris), at Mont Souris there is a great abundance of inorganic matter and particles of carbon, due to the combustion of fires and the cleaning of the streets, &c. During rain there is an immediate and almost complete disappearance of these matters. Miquel ("Organismes Vivants de l'Atmosphere") warns us that the nature of the particles of dust floating in the air is so varied that one of the first necessities of the experimenter is some sort of classification.

The mineral matter is very varied, carbonaceous, ferruginous, silicious, or cretaceous. These mineral particles may be submitted to chemical tests for the determining of their nature. Sometimes their rough angles and general appearance at once show that they are not organised, but this is not always the case, and since the divisibility of these mineral particles is infinite it is not possible, very often, to distinguish them, by their appearance alone, from micro-organisms of the family of bacteria.

The coarse particles present in the air are not without their use, as they give, as Pouchet said, a character to the whole of the floating matter collected, and enable the observer to say very often whence the air has come. The air of rooms, for example, contains a quantity of coloured textile particles which are seldom met with in the air of the country. In the streets we find in the air the detritus of clothing, but the textile particles are more rare, and are diluted, as it were, with matters of vegetable and animal origin. In the country, the chief part of the organised matter is formed of vegetable fibres.

The dust of the air is usually collected by exposing a glass slide, previously smeared with some sticky fluid, to the air-current. In making choice of fluid care must be taken that it is not of a character to encourage the growth and multiplication of organic particles, such as the spores of fungi. Miquel asserts that glycerin alone is not suitable, because it attracts water, and then forms a most active cultivating medium. He advises a mixture of glycerin and glucose, which he says is stable, colourless, transparent, and very sticky.

Another difficulty in the examination of the dust of the air is the measuring of the volume of air which passes over the dust trays. Unless this be done, it is evident we get no exact knowledge as to the relative purity or impurity of the air examined. I do not propose to enter into details of the machines for aspirating known quantities of air, but it must suffice to say that at Mont Souris the difficulties of measurement seem to have been completely overcome.

As to matters which are visible with the aid of the microscope, Miquel says, "Apart from the ova of infusoria, whose existence in air-dust is very uncommon, as well as the bacteria, which are indistinguishable among the other matters, we have to deal with:—1. Starch grains. 2. Pollen grains, capable of fertilising other plants of their own species, but incapable of germination. 3. Spores of cryptogams, capable of germinating, and of giving rise to determinate forms of fungi. 4. Complete plants, generally uni-cellular.

Pollen is very common in the spring and summer, and tends to disappear in the autumn and winter. It never completely disappears, even in the winter. In Paris, the amount of pollen found in the air is sometimes very great, and may amount to as much as 5,000 or 10,000 grains per cubic metre.

Spores of cryptogams are the most common of all organic particles found in the air.

Chief Characters of Air-Dust.

	Spores.		Pollen.	Mineral.
	Young	Old		
In summer—wet......	Many	Few	Much	Little
„ —dry......	Few	Many	Much	Much
In winter—wet	Few	Few	None	Little
„ —dry	None	Many	Little	Much
In dwellings, &c......	Few	Many	Very few	Very much
In sewers	Many	Few	None	Little

So far we have been considering particles which are comparatively gross—microscopic certainly, but, nevertheless, plainly visible under the microscope, and distinguishable the one from the other by the eye of the expert.

The lower forms of fungi, the so-called schizophytes, which increase almost entirely by the simple process of splitting and dividing, are very much more difficult of detection. Though small, these fungi are by no means to be neglected, for to them belong the bacteria and allied kinds of which we have heard so much of late. These fungi are known to be the cause of some forms of putrefaction, to be the cause of sour milk, rancid butter, ropy beer, &c. They have been found in connection with many most virulent diseases, and are known to be the active cause of some of them. Hence it follows that the study of the bacteria in the air is deemed at present to be of the highest importance. When in small numbers, and when mixed with other matters, they elude the eyes of the most careful investigator, so that recourse must be had to other methods of investigation.

Such a method of investigation is found in what are daily becoming more and more familiar to us, as cultivation experiments.

Of the precautions necessary in conducting such experiments, and of the enormous care and trouble which they involve, I will say nothing; but I will merely state that, in principle, the experiment consists in bringing a measured quantity of air in contact with a putrescible fluid which has been previously sterilised. At Mont Souris, the fluid used is a *bouillon* of beef. It is sterilised by repeated heating, and if, after a month or so, the tube containing the *bouillon* is found to be clear and transparent, and without change, then it is fit for testing the air.

The sterilised tubes are unsealed, a measured quantity of the air to be tested is drawn through them, and they are then re-sealed and kept for several days in a uniform warm temperature. If at the end of this time no change has taken place, then we have no evidence that the portions of air admitted to the tube contained any bacteria; but if the contents of the tube become cloudy and present evidence of bacterial growth, then the portion of air admitted to the tube contained at least one active germ capable of growth. M. Miquel has been in the habit of distributing the air to be examined in a large number of sterilised tubes. For example, he would take 100 litres of air from this room, and inoculate with it 50 tubes containing sterilised *bouillon*; if, after this, ten of the tubes showed bacterial growth, he would know that his 100 litres of air contained at least ten active bacteria, and he would state the bacterial richness of the air as equal to 100 bacteria per cubic metre.

It must be remembered that this and similar manœuvres have been practised day after day, and sometimes several times a day, at Mont Souris; and I will ask you to think for a moment of the immense labour involved, and of the enormous quantity of material necessary—the thousands of tubes, the gallons of sterilised *bouillon*, and the amount of subsidiary apparatus.

The expense involved in such extensive investigation is not small either, and we cannot but admire the spirited action of the Paris Municipality in establishing this most important observatory.

There are many ways of carrying out the experiments for testing the purity of the air, and in the hands of different workers the details have been much varied.

I propose to show you, with the assistance of my friend, Mr. Joseph Lister, a rough method of treating the purity of the air by means of a potato. I have upon the table two bell-jars and an old potato, to which I will invite your attention. We have been at some pains to deprive this potato of all living germs. To this end it has been cleaned, and its outer skin has been washed with a coating of corrosive sublimate, which is about the most powerful antiseptic known. Further, our potato has been subjected to a prolonged steaming, which has thoroughly cooked it. We may assume that the potato has been in this way freed from living germs, or, in other words, that it is sterilised.

We next take one of the bell-jars, and wash its interior with corrosive sublimate solution, so as to kill any germs which may be adhering to it, and further we heat the interior with the flame of a spirit lamp, so as to destroy any living thing that may be in the contained air. Next, we remove the potato from the vessel where it has been steaming, and cut it in halves with a knife, the blade of which has been previously heated in the flame of a spirit lamp. One-half we place under the sterilised bell-jar, the other half we will leave exposed to the air of the room for a few minutes, and then place it under the other bell-jar. In order to keep the air in the bell-jars moist, we place some blotting paper, moistened with a

solution of corrosive sublimate, in each. We will now put these potatoes away in a cupboard, and examine them again at the next lecture. We ought to find that the half potato which has been kept under the sterilised bell-jar will remain free from growths, while if, as I suppose, the air of this room be charged with living organisms, then we shall find upon the half potato which has been exposed to it centres, more or less nnmerous, of fungoid and bacterial growth.*

This is but a rough method, no doubt, but it is often of great service. It does not, like the more elaborate method of Miquel, give you anything like an exact quantitive estimate of the richness of the air in living microbes, but it gives a rough idea, and it will serve to give a rough idea to you of the nature of the experiments which are necessary for testing air for bacteria and allied organisms.

I will now bring before you some of the results of Miquel's experiments. Bacteria in the air, like the spores of fungi, are liable to great variations. In the year 1880, there were, on an average, 560 bacteria in each cubic metre of air examined at Mont Souris. In 1881, the average was 590, while in 1882, the figure reached was only 320. In the "Annuaire de Mont Souris" for 1884, M. Miquel gives the weekly average of bacteria found at Mont Souris from January, 1880, to October, 1883. These are given, arranged in parallel columns, with the meteorological data for the same period (barometric pressure, heat, moisture, wind, electricity, ozone, rainfall). From a careful examination of these figures, Miquel has arrived at the opinion that bacteria are apt to increase during periods of high barometric pressure, a rule, however, which is by no means absolute.

Changes of temperature do not produce very sudden changes in the number of bacteria. Sudden increases are, without doubt, most common in summer, but prolonged heat often causes a diminution in the number of microbes. Miquel believes that the thermometer may give the key to certain seasonal variations, but that changes of temperature will not explain the weekly variations.

Bacteria reach their maxima when the hygrometric conditions are feeble, *i.e.*, when the air is dry. This is explained by the fact that moist conditions of atmosphere correspond with times of heavy rain, and when the surface of the ground is sodden, which are always periods of few bacteria.

The direction of the wind has a very decided influence on the number of microbes collected at Mont Souris, which, be it remembered, is situated in the extreme south of Paris. Of thirty maxima (over 600 microbes per cubic metre of air) observed at Mont Souris :—

14	occurred	with the	wind	N.E.
4	,,	,,	,,	N.
4	,,	,,	,,	N.W.
2	,,	,,	,,	W.
5	,,	,,	,,	S.W.
1	,,	,,	,,	E.

With regard to the relationship between ozone and bacteria, Miquel admits that when ozone is in small quantities, bacteria often increase. He gives, however, no credence to the belief which has been put forward by some, that ozone destroys bacteria. The relationship observed between ozone and the number of bacteria is illusory, and is caused by a meteorological condition which is capable at once of producing ozone and lowering the number of microbes. Rain and moisture have, apparently, this double power.

For the year 1882-83, Miquel made calculations for every three days, and comparing the number of bacteria with the rainfall, he came to the conclusion, or rather was confirmed in a conclusion which he had arrived at three years previously :—

"The number of aerial bacteria, which is always slight during times of rain, increases as the drying of the soil progresses, and decreases if the dryness is prolonged beyond a week."

The seasonal changes of bacteria observed at Mont Souris in 1882-83 were as under :—

Autumn	115	microbes per cubic	metre.
Winter	115	,,	,,
Spring	550	,,	,,
Summer	?	,,	,,

The enumeration of bacteria was carried on, not only at Mont Souris, but also in the Rue de Rivoli, which is near the centre of the great City of Paris. This work was intrusted to M. Riquet, under the guidance of M. Miquel, and from these researches carried on since January, 1881, the following seasonal averages have been deduced :—

* These potatoes were examined at the concluding lecture, with the result that the protected potato showed three centres of growth, as against eleven on the potato which had been exposed to the air of the room.

1882-83 (Rue de Rivoli).

Autumn....	2,060	microbes per cubic metre.
Winter	2,040	" "
Spring	1,900	" "
Summer....	3,960	" "
Yearly mean	2,490	" "

Microbes at High Altitudes.—In conjunction with M. Freudenreich, of Berne, M. Miquel investigated the question of the richness in microbes presented by the air of high altitudes. Many investigators have touched this question, but the difficulties of experimenting are very great, and most of the earlier experiments are seriously tainted with error.

The method pursued by Messrs. Miquel and Freudenreich was as follows:—A glass tube was drawn to a point at one end. A plug of spun glass (*coton de verre*) for filtering the air was thrust towards the point, and retained in position by a slight contraction in the tube behind it. A second plug of spun glass was thrust down to the contraction, and then, the point being sealed, the tube was submitted to a temperature of between 200° and 300° C. for some hours. After cooling, the open end is closed with a cork.

The method of conducting the experiment is as follows:—The tube is mounted on a stick, and, the cork being removed, it is placed with its capillary point slightly raised, and facing the wind. An aspirator is then fixed to the open end, and the fine point is removed by means of the blowpipe and a pair of heated forceps. By means of the aspirator, a measured quantity of air is then drawn over the sterilised plug of spun glass. The pointed end is then re-sealed, and the cork replaced. The plugs are then removed, and stirred up with 30 or 40 c. c. of sterilised water, and this water is distributed in any number (ten, twenty, thirty) of flasks of sterilised *bouillon*, which are then kept at a temperature of 30° C. to 35° C. Knowing, on the one hand, the number of successful cultivations in the *bouillon*, and, on the other, the volume of air which had been drawn over the sterilised cotton wool, it is easy to estimate the number of microbes in any known quantity of air.

The following are the details of a few of the experiments carried out by these two enthusiastic observers:—

On July 12, 1883, M. de Freudenreich left Thun, and climbing the Bernese Alps, reached the neighbourhood of the Strahlegg Pass, at an altitude of 3,200 metres, and filtered through a plug of spun glass (at a height of one metre above the ice) 300 litres of air. A week later he distributed this plug among twelve portions of sterilised *bouillon*. Two and a-half months later, no growth had taken place in the *bouillon*, which remained absolutely limpid.

Three weeks later, two portions of air, of 500 and 400 litres respectively, and taken from altitudes of 2,100 metres and 3,976 metres, were filtered through sterilised plugs, and the plugs were afterwards distributed through portions of *bouillon*, but no growth took place, the *bouillon* remaining perfectly limpid.

In a third experiment, M. de Freudenreich filtered 1,500 litres of air through six plugs on the top of the Schilthorn, at a height of 2,972 metres; the subsequent cultivation experiments gave, as in the other cases, negative results.

"Thus," says M. Miquel, "2,700 litres of air taken from elevations varying from 2,000 to 4,000 metres above sea-level, did not furnish either a bacterium or spore of fungus capable of cultivation and growth in neutralised *bouillon*, a liquid possessing the highest powers of developing schizophytes and fungi; for at the observatory of Mont Souris it is common to see 400 or 600 fungoid spores per cubic metre of air developed in the *bouillon*."

With air taken on the level of the town of Thun, M. de Freudenreich's results were very different. The results may be expressed as follows:—

Bacteria in Ten Cubic Metres of Air.

1. At a height of from 2,000 to 4,000 metres	0·0
2. On the Lake of Thun (560 metres)	8·0
3. Near the Hotel Bellevue, Thun	25·0
4. In a room of the hotel	600·0
5. In the park at Mont Souris	7600·0
6. In the Rue de Rivoli (Paris)	55000·0

These analyses were all made about the same time—

"In giving these results," says M. Miquel, "I do not pretend to establish, even approximately, the comparative richness in microbes of the air of Switzerland and Paris. In order to firmly establish such a fact, a prolonged series of experiments would be necessary. But the above results enable us to conclude forthwith that the air of the Valley of Thun is very poor in germs. The objections might be made that I had allowed my air-dust to remain eight or ten days on the filter plugs prior to the attempts at cultivation. This might have the effect of lowering the number of bacteria, because some of the germs might die in the interval of falling on the cotton, and subsequent immersion in the *bouillon*. But this supposition cannot constitute a serious ob-

jection, for experiments show that the tenderest bacteria will resist five or six months drying, and that micro-cocci preserve the faculty of reproduction for years."

The diminution of microbes in the air of the Swiss mountains seems to Miquel to be due—

1. To the diminution of atmospheric pressure. At a height of 4,000 metres, a volume of air from the plain would occupy twice its original space, and thus the atmospheric dust is diluted.

2. To the lessened density of the air, which becomes less and less able to hold solid bodies in suspension.

3. To the progressive disappearance of the productive foci of bacteria. At the snow-line the disappearance of these foci is absolute.

To give an idea of how the atmospheric purity increases as we rise perpendicularly above the sources of microbes and infecting particles, Miquel mentions the result of two analyses of air obtained simultaneously; the one in the Rue de Rivoli, and the other from the top of the Pantheon, the difference in elevation being 100 metres. At the lantern of the Pantheon the air is twenty times more pure than at the Mairie of the 4th arrondissement, situate in the Rue de Rivoli.

Many other reasons for the rarity of germs at high altitudes might be invoked. Among these the cold is not without influence, although the power of cold to kill microbes has always seemed to M. Miquel to be feeble. In December, 1879, Miquel submitted some sealed tubes containing bacteria in distilled water to a temperature of —7° C. for twenty days, and subsequently to a temperature of —30° C., but without destroying the vitality of the bacteria. In 1881, a director of the Swiss Ice Company sent to M. Miquel a block of ice eleven months old, weighing 50 kilogrammes, and which had been taken from the Valley of Joux. In three samples taken from the centre of this block M. Miquel found examples of a micrococcus of the nature of sarcina, and he calculated that this block contained 780,000 bacteria which were still alive.

In December, 1882, by the kindness of Prof. Raoul Pictet, of Geneva, M. Miquel was enabled to submit some of his tubes containing bacteria to a temperature of — 100° C., and in this experiment it was found that many bacteria which are unable to resist a temperature of 70° C. for two hours were able to withstand this degree of cold. One fact was noticeable, viz., that some of the bacteria had "grown old," as Miquel puts it, and when they were sown in nutritive liquids, growth was delayed for three days, instead of being observable at the end of twenty-four hours, as is usually the case.

M. Miquel's researches on the air of the wards of hospitals were carried out at the Hotel Dieu and the Hospital Notre Dame de la Pitié, and with the result, that for the whole year the hospital air contained on an average 11,100 bacteria per cubic metre, as against 850 bacteria per cubic metre of the air of the Rue de Rivoli.

Taking the whole year through, it was found that the increase and decrease of bacteria in the air of hospital wards obeyed laws very different from those observed in the open air. The hospital bacteria, in fact, reached their minimum at the time when the windows could be kept open, *i. e.*, in June, July, and August, when the numbers fell to about half of the average, viz., 5,500, at a time when the bacteria in the street had attained a maximum of about 1,300, or 50 per cent. in excess of the average. The maximum of the hospital (28,000) was reached in January, when the weather was cold and the windows shut, and the average in the street had fallen to 160.

Reflecting on this curious and interesting result of his inquiry, M. Miquel says:—"If hospitals be built in the middle of cities, the surrounding quarters must receive microbes which possibly are not always harmless," and he quotes M. Bertillon in support of his proposition. M. Bertillon says:—

"I wish to point out the lessening week by week, and the final cessation on the 17th week of this year, 1880, of deaths from small-pox in the quarters of the Sorbonne, which was so exceptionally smitten by the malady in January, February, and March, for the diminution no less than the aggravation will serve to show the cause of the ravages. By referring each case of small-pox to the house in which it had originated, we found them grouped round the annex of the Hotel Dieu, as round an epidemic centre squeezed in between the Seine and the Boulevard St. Germain. In this district, with 10,000 inhabitants, there were forty-nine deaths from small-pox in January and February, notwithstanding that its due proportion, having regard to the population and the intensity of the epidemic, would have been three. How are these forty-six deaths in excess of the average for the rest of the city to be accounted for, except by the fact that the annexe of the Hotel Dieu, around which the stricken houses were situated, had at the time been made a depôt for small-pox cases, whither they were all sent for the laudable purpose

of isolation. This measure seems to have changed the mode of transmission rather than to have suppressed it, and the small-pox, instead of going from bed to bed, spread from house to house round the variolous centre, aud now that the depôt had been closed, the small-pox is disappearing."

The annex of the Hotel Dieu being closed, the small-pox patients were sent to another hospital, and M. Bertillon says :—

"Attention is directed to the ravages of small-pox in the quarter of Quinze Vingts, and the neighbourhood of Sainte Marguerite and La Roquette. These districts continue to register three or four times their due amount of small-pox. These ravages are but too easily explained by the presence of the St. Antoine Small-pox Hospital, which has replaced the annex of the Hotel Dieu. During the first three months of the year the hospital contained 100 small-pox patients, and thus the contagion with which the annex of the Hotel Dieu was poisoning the Sorbonne were moved to these quarters. The contagion was imported with the patients by the administration, who thus furnished an experimental proof of our former conclusions."

M. Miquel's examination of dust and soil shows that these swarm with bacteria, and that, as regards dust deposited on free surfaces, it contained bacteria unproportional to the richness, in that respect, of the air whence the dust was deposited.

The Mont Souris experiments clearly show that the number of living organisms in the air are in direct proportion to the density of population. On mountain solitudes they are fewest; at points elevated above crowded cities they are comparatively scarce; at the Park of Mont Souris, on the outskirts of Paris, they are far less numerous than in the centre of Paris, as in the Rue de Rivoli; and the numbers in the Rue de Rivoli, large as they are, become insignificant when compared with the quantity detected in the air of crowded dwellings and of hospitals. We have seen that in crowded cities, and still more in crowded rooms and homes, carbonic acid is present in the air in greater or less extent, and we have come to the conclusion that the carbonic acid *per se* is probably not very harmful, but that carbonic acid always comes in bad company, especially in the company of organic matter, which gives the close organic smell to crowded places. Part, at least, of the organic matter is, we now know, composed of micro-organisms, such as micro-cocci, bacteria, and bacilli.

Why should we attach so much importance to these micro-organisms? There are a great variety of them, and the differences of their appearances are so slight that by the eye alone, even when aided by the highest powers of the microscope, it is impossible to distinguish many of them apart. Many of them play a part in the economy of nature which we must all recognise as of the highest importance. They are the great agents of putrefaction and decay; they are the active cause, as it were, of the breaking up of effete organic matter into its simple chemical elements. They are essential for the complete round of changes which we see going on around us. The animals prey upon each other, and on plants. The plants live on organic refuse, both animal and vegetable, but before organic refuse can become fit food for the higher plants, it becomes the prey of those low vegetable organisms which are the cause of putrefaction and decay, and which are to be found in the air, the water, and the soil, ready at all times to perform their mission.

It used to be thought that in order to stop putrefaction and decay, the "exclusion of the air" was, before all things, necessary. It has of late years been proved that the gases of the air are powerless, of themselves, to produce putrefaction, decay, or the allied process of fermentation; and that if the air be freed from micro-organisms, putrescible matter will remain unchanged for months or years. When an organic body ferments, or putrefies, then things happen which cannot but demand our attention. These are—(*a*) the giving off of gas which is mainly carbonic acid, but which may be mixed with other offensive smelling gases; (*b*) the multiplication of the organism which is the cause of the ferment, so that the fermenting or putrefying mass becomes a focus for the dissemination of the organism; (*c*) a chemical change in the fermentible body. During vinous fermentation, alcohol is formed; and during some forms of putrefaction, bodies of the nature of alkaloids are formed which are actively and quickly poisonous.

Ordinary putrefaction has long been recognised as an occasional danger to health, and irritant poisoning from eating putrid food is no very rare occurrence. What is known as "antiseptic surgery," which we owe to the genius of Sir Joseph Lister, consists in measures calculated to prevent putrefaction in wounds, whether the result of accident or the surgeon's knife. The putrefying of the wound is the cause of blood poisoning and death,

and it is now known that if a wound can be kept sweet, it is hardly a source of danger to the patient, no matter what its extent may be. A putrefying wound may cause death in two ways—(1) by the entrance of the organism into the blood of the patient, and its subsequent growth in his body; and (2) by the absorption of the poison which is formed during putrefaction. In the former case death is gradual, and in the latter case it is sudden.

By the skill of experimenters, many of the micro-organisms have been differentiated and propagated by pure cultivation in fluids and semi-solids of a suitable constitution, and in this way, assisted by other methods of experiment, it has been shown that particular organisms are invariably associated with certain diseases, and that in some cases the organism is the veritable cause of the disease.

Thus it may be considered as proved beyond doubt that erysipelas is due to the growth of a micrococcus in the skin, and that splenic fever of cattle is due to the growth of a bacillus in the blood. Definite micro-organisms have been discovered to be inseparably connected with tubercular disease, pneumonia, glanders, relapsing fever, ague, typhoid fever, and it is only a matter of fair inference that if the case is proved in regard to a large number of these infective or zymotic diseases, a similar basis of causation will be found in connection with the others.

Since micro-organisms are found to be definitely connected with disease, and since micro-organisms are found not only in the soil and water, but may be raised by the wind and transported any distance, the study of these organisms in the air is of prime importance from the point of view of health.

Now the conditions of growth of these organisms have been studied with great care, and it is found that they only grow and flourish under certain conditions. The most important condition is a suitable amount of warmth and moisture. The most favourable temperature seems to be, broadly speaking, between 60° Fah. and 100° Fah. Cold checks their growth, as likewise do high temperatures.

We know how putrefactive changes run riot when the weather is warm and moist, and the history of cholera, plague, and yellow fever show what may be the ravages of zymotic disease in tropical climates; and the recent researches into the life history of micro-organisms makes it impossible for us not to see the strongest analogy between the two conditions.

While the evidence that many diseases which affect the human race are caused by the growth of parasitical fungi in the tissues of our bodies is so strong, and is gathering strength so fast as to be almost unanswerable, we have to remember that for the growth of a micro-organism to produce disease, just as for the growth of a food-plant, something more is necessary than spore or seed, moisture or temperature.

That something is a suitable soil. All agriculturists know that very small differences in soils make very great differences in the growth of plants. In one field we may have a stunted crop choked by weeds, and a prey to parasites, while in the next field we may have the same plant showing a vigorous and healthy crop, a crop whose very vigour makes it difficult for weeds to flourish. On inquiry, we may find that the soil of the two fields was originally the same, but that the addition of a small quantity of suitable manure, ammonia, nitrates, phosphates, potash, lime, or what not, has caused a vigorous growth in the one case, while the want of it has prevented vigorous growth in the other case. This is an every day experience.

Messrs. Lawes and Gilbert have, for years past, been making most valuable experiments on the effects of different manurial bodies. With crops which take six or eight months to come to perfection, experiment is but a slow method of gaining knowledge; and it is evident that experiments made in the field must lack much of the exactness which is obtainable in the laboratory.

In Dr. Duclaux's admirable little work on "Fermentation," which was written at the request of the Council of the recent Health Exhibition, will be found an account of some experiments carried out by M. Raulin.

M. Raulin devoted his attention to one of the commonest mould fungi, the *Aspergillus niger*. The spores of this fungus, when sown in a suitable soil, soon produce a mass of white branching threads, the so-called mycelium; and then there appear the spore-bearing filaments, whose black *capitula* make the mass look like velvet. This fungus grows readily on pieces of bread moistened with vinegar, or on slices of lemon, and generally on acid fruits and liquids.

By a series of experiments, however, M. Raulin devised a liquid in which the *aspergillus* grew with the greatest uniformity, so that crops of the fungus grown on equal quantities and areas of the liquid differed from

each other only to the extent of 5 per cent. The composition of Raulin's liquid for the growth of the *aspergillus* is as follows:—

	Grammes.
Water	1,500·00
Sugar candy	70·00
Tartaric acid	4·00
Nitrate of ammonia	4·00
Phosphate „	0·60
Carbonate of potassium	0·60
„ magnesium	0·40
Sulphate of ammonia	0·25
„ zinc	0·07
„ iron	0·07
Silicate of potassium	0·07

The growth requires free exposure to the air, as the fungus needs a good supply of oxygen. A temperature of nearly 35° C. is found to be most favourable to it; and it grows best when the liquid is spread in a layer of two to three centimetres of depth over a shallow porcelain dish. If under these conditions the spores be sown, we find in twenty-four hours that the liquid is covered with a white layer of mycelium; the fructification begins, and in three days the cycle of changes is complete, and the crop is ripe. The first crop is removed, and more spores are sown, and at the end of three days there is a second crop. The two crops are then dried, and are found to weigh twenty-five grammes, and the nutritive liquid is exhausted.

Here, then, is an experiment on manures and soils which is complete in six days, and which is so manageable that thousands of experiments might be perfected within a year. Further, it has all the elements of exactness and precision.

Now the growth of a plant is a struggle between it and other organisms. All organisms have their enemies and their parasites, and must destroy them or be destroyed by them. The *aspergillus* is no exception, but in Raulin's liquid it flourishes, and none of its enemies get ahead. The *aspergillus* is stronger than its enemies, because it finds in Raulin's liquid all the elements which it requires. If one of these elements were to fail it would still live, but with difficulty, and its power of resistance would diminish. If several were to fail, then it would dwindle, fade, and make way for a neighbouring species of a less exacting nature, or having other requirements more easily fulfilled in a medium which has become a poor one for the *aspergillus*, but a rich one perhaps for the other species.

M. Raulin made comparative experiments, growing the plant (*a*) in the complete liquid, and (*b*) in the liquid minus one or other of its constituents. Here are some of his results:—

		Grammes.
1.	With the liquid complete	25·000
2.	„ minus potassium	1·000
3.	„ „ phosphoric acid	0·125
4.	„ „ ammonia	0·002
5.	„ „ the zinc	2·005

The effect of the withdrawal of the zinc is most remarkable, when we consider that in the 7 milligrammes of the sulphate there are but 3·2 milligrammes of zinc, constituting the $\frac{1}{50000}$ part of the fluid. The action of such a minute quantity of metal represents an increase of 22·5 grammes to the crop, *i.e.*, a weight of plant equal to 700 times its own weight.

Further, it has been stated that the $\frac{1}{1600000}$ part of nitrate of silver stops the growth altogether, and so sensitive is the plant to the action of silver, that the growth will not even commence in a silver vase. The growth is similarly stopped by $\frac{1}{50000}$ part of corrosive sublimate, by $\frac{1}{8000}$ of bichloride of platinum, and $\frac{1}{240}$ of sulphate of copper.

The withdrawal of iron from the liquid produces results similar to the withdrawal of zinc, while the addition of 1 gramme of iron to the liquid will increase the crop by 800 grammes. Notwithstanding this, the functions of the zinc and iron are quite different. Zinc enters the plant as one of its constituent elements, iron does not. The use of the iron is said to be to destroy or suppress, pending production, a poison which the plant secretes, and which, were it to accumulate, would end by killing the plant.

These experiments of Raulin's are most instructive, as showing us what apparently insignificant trifles may cause an organism to flourish or languish. Many of the micro-organisms connected with disease are cultivated with ease in artificial media, while the attempt to cultivate others has proved unsuccessful. This want of success is not to be wondered at, when we consider the effect of $\frac{1}{1600000}$ part of nitrate of silver in checking the growth of the *Aspergillus niger*.

The effect of the minimal quantities of certain ingredients in "soils" (using the word as signifying all propagating media) enables us to frame an hypothesis for the explanation of certain phenomena connected with disease. Why is it, for example, that many of the zymotic diseases only occur, as a rule,

once in a lifetime, and that one attack is preventive of subsequent attacks? This strange phenomenon is readily explained, if we may assume that the micro-organism or zyme, by its growth, deprives the blood or the tissues of some ingredient (absolutely insignificant) without which the disease germs cannot flourish.

If, after the lapse of time, this hypothetical ingredient re-accumulates, then the body is ripe for a second attack of the malady. In like manner the effect of minimals on the growth of organisms may afford an explanation of why it is that zymotic diseases become epidemic, why at one time they involve a small area, and at another time a large area, and yet the cause may elude our coarse vision. In the old days, when it was the fashion to inoculate for the small-pox, the inoculated disease was generally milder and less dangerous than the disease contracted in the ordinary way, the reason being probably that when the disease was inoculated the patient's body was not in the highest state of efficiency for growing small-pox, if such an expression may be used.

The effect of minimals on the growth of organisms may afford an explanation of why it is that some diseases seem to flourish more in some families than in others. Why, for example, does scarlet fever fall heavily on some families for successive generations; and how comes it that consumption, which is almost certainly dependent on an organism, is so clearly hereditary? If we may assume that what is known as "family constitution" is an aptness on the part of the blood and tissues to grow this or that organism, the explanation is easy.

Seeing how omnipresent are the micrococci, bacteria, and bacilli, of which we have been speaking, how they infest the air, the soil, the water; and seeing again that it is an undoubted fact that the organisms of disease may live and grow in suitable putrescible liquids outside the human body, it is almost a matter of surprise that we are any of us alive to discuss the question. From what we have been saying, however, it appears that for the flourishing of infective organisms three things are necessary, in addition to the organism, viz., some degree of warmth, a suitable condition of moisture, and a "soil" apt to grow the organism. It is when we get the coincidence of all the conditions that we get the disease in its marked form. The cold of the Arctic winter seems to be sufficient to prevent putrefaction, and to prevent the spread of many of the zymotic diseases. In tropical countries, where putrefaction flourishes, zymotics flourish, and if we want to enjoy health in hot countries we must exercise the greatest care and circumspection in dealing with all putrescible matters, whether excremental or otherwise; finally, it is only unhealthy persons who become a prey to parasites, and a healthy man is probably more than a match for most of the so-called pathological organisms.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The number of visitors to the Exhibition for the week ending Tuesday, 7th inst., was 161,844. Total since the opening, 1,315,474.

PATENT-OFFICE REPORT.

The Comptroller-General of patents, designs, and trade marks, has issued, in the form of a Parliamentary paper, his report, the second since the passing of the Act of 1883. That the new Act has worked well in the interest of inventors may be seen from the fact that the number of applications for patents, which had risen, with some variations, almost constantly in the course of thirty years, from 1,211 in the year 1852, to 6,241 in 1882, leaped with a bound to 17,110 in 1884. There was a slight depression in 1883, possibly on account of the change of the law, which makes last year's numbers the more remarkable. The increase is in fact, as between the years 1883 and 1884, no less than 195 per cent. The report claims an increase of about 280 per cent. for this year, on the average of 1882-83. This must be a misprint for 180 per cent., for the increase claimed is not borne out by the figures, which are for 1882, as has already been said, 6,241, and for 1883, if the report be correct, 5,993, or an average for the two years of 6,117. This represents an increase of 189 per cent. on the average of the two years. Seventy-nine per cent. of the applications were made by persons resident in the United Kingdom, namely 12,356 being residents in England and Wales, 901 in Scotland, and 254 in Ireland. Of the rest the largest numbers were from the United States, 1,181, from Germany 890, and from France 788. Residents from 27 other countries also made application to the office, 13 such countries being British possessions, from which 175 applications were made, and three, it may be

added, were made from Egypt. Only three appeals were made in the course of the year against the decision of the Comptroller, so that it may be taken that his decision is almost invariably satisfactory to applicants. The greatest number of applications made in any month was in January, 2,499; the smallest in August, 992. The greatest number made in any single day was, as might be supposed, on January 1, 266. The total number of patents sealed upon the 17,110 applications will not be known before next year. The number of readers who frequented the Free Library of the Patent-office in 1884, was 39,508, as against 32,748 in the previous year. Sets of the publications of the office have been sent to forty-six towns, to a large number of public offices, and seats of learning in the United Kingdom; to nine British colonies, and to nine foreign States. Complete series of abridged specifications have also been sent to nearly 280 mechanics' literary and scientific institutes in various parts of the United Kingdom and United States. The number of designs registered in 1884 was 19,515, as compared with 17,166 in 1883; and the number of trade-marks applied for was 7,104, to 4,105 in 1883. The receipts of this office amounted to £103,827, of which £88,996 was for patents' fees, £3,477 for designs' fees and stamps, £7,014 for trade-marks' fees, and more than £4,000 for the sale of publications. The chief payments made were £36,225 for salaries—all of which are set forth in detail in the report—and £17,000 to Messrs. Eyre and Spottiswoode for printing. There was a surplus income of nearly £40,000. Tables are added showing the different classes of designs and trade-marks, with the fees paid for each.—*The Times.*

SCIENCE AND ART DEPARTMENT.

The following prizes, scholarships, associateships, &c., have been awarded in connection with the Normal School of Science and Royal School of Mines at South Kensington.

First Year's Scholarships. — James Rodger, Andrew McWilliam, Tom H. Denning, and John Richards.

Second Year's Scholarships.—Arthur E. Tutton, and Thomas Rose.

The following prizes were also awarded:—Alfred V. Jennings, the "Edward Forbes" medal and prize of books for biology; Arthur E. Tutton, the "Murchison" medal and prize of books for geology, and the "Tyndall Prize" of books for physics, Course I.; Henry G. Graves, the "De la Beche" medal for mining; John C. Little and James Allen, "Bessemer" medals, with prizes of books from Professor W. Chandler Roberts for metallurgy; Arthur W. Bishop and Peter S. Buik, the Hodgkinson prizes for chemistry.

Associateships, Normal School of Science.—Isaac I. Walls (chemistry, second class); Alfred Fowler (mechanics, first class); George H. Wyatt (physics, second class); Martin F. Woodward (biology, first class).

Associateships, Royal School of Mines.—John C. Little (metallurgy, first class); Thomas A. Rickard (metallurgy, first class); Percy E. O. Carr (metallurgy, first class); Walter A. A. Dowden (metallurgy, second class); Henry G. Graves (mining, first class); Ernest Woakes (mining, first class).

General Notes.

Royal Archæological Institute. — The annual meeting of the Institute will be held at Derby from Tuesday, July 28th, to Wednesday, August 5th, inclusive. The presidents of the three sections will be:—*Antiquarian*, the Rev. J. C. Cox, LL.D.; *Historical*, the Dean of Lichfield; *Architectural*, the Right Hon. A. J. Beresford-Hope.

Congress of Archæologists, Antwerp.—Arrangements are being made by the Belgian Academy of Archæology for holding an International Congress of Archæologists in connection with the Antwerp Exhibition. A Commission has been appointed by the King of the Belgians, of which Colonel Wauwermans is the president, and M. Henri de Radiguès the secretary. M. Ch. Ruelens is specially appointed to represent the Belgian Government at the Congress.

Silver Mines of Bolivia.—The Bolivian Government levies a tax of 4s. 6d. for each ounce of silver, and this—says the United States Minister at La Paz—has been farmed out. The product of the mines of Bolivia is estimated at 16,000,000 oz., and this amount appears to be increasing as new machinery and methods are being introduced. The Huanchaca mines, situated in the southern part of Bolivia, in lat. 20° S. and long. 67° W., in a south-western direction from Potosi, are considered the richest, and produce about 5,600,000 oz. Potosi is still productive after being worked over 250 years, and yields annually about 1,200,000 oz.; and the mines of Oruro produce about 1,200,000 oz. The Guadelupe, situated about 100 miles south of Potosi, yields about 1,300,000 oz., making a total of 9,300,000 oz. The Colquechaca mines in the province of Aullagas, about lat. 18° S., directly north of Potosi, are considered the richest after those of Huanchaca, and it is estimated that they yield about 3,200,000 oz. There are many small mines distributed over the Bolivian-Andean plateau which produce well, the estimated quantity for the year 1883 being 3,500,000 oz., making a grand total of 16,000,000 oz.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CHAIRMANSHIP OF COUNCIL.

On Monday last, 13th inst., at their first meeting, the Council elected Sir Frederick Abel, C.B., D.C.L., F.R.S., as Chairman for the ensuing year. The various committees were also re-appointed.

Proceedings of the Society.

CANTOR LECTURES.

CLIMATE IN ITS RELATION TO HEALTH.

By G. V. Poore, M.D.

Lecture III.—Delivered January 26, 1885.

Diseases caused by Floating Matter in the Air.

The information which modern methods of research have given us with regard to the floating matter in the air, is of an importance which cannot be over-estimated.

That the air is full of organic particles capable of life and growth is now a matter of absolute certainty. It has long been a matter of speculation, but there is a great difference between a fact and a speculation. An eminent historian has recently deprecated the distinction which is conventionally drawn between science and knowledge, but, nevertheless, such a distinction is useful, and will continue to be drawn. A man's head may be filled with various things. His inclination may lead him, for example, to study archaic myths in the various dialects which first gave them birth; he may have a fancy for committing to memory the writings of authors on astrology, or the speculations of ancient philosophers, from Aristotle and Lucretius downwards. Such a one may have a just claim to be considered a man of learning, and far be it from me to despise the branches of knowledge towards which his mind has a natural bent. But in so far as his knowledge is a knowledge of fancies rather than facts, it has no claim to be called science. Fancies, however beautiful, cannot form a solid basis for action or conduct, whereas a scientific fact does. It is all very well to suppose that such and such things may be, but mere possibilities, or even probabilities, do not breed a living faith. They often foster schism, and give rise to disunited or opposed action on the part of those who think that such and such things may not be. When, however, a fancy or a speculation becomes a fact which is capable of demonstration, its universal acceptance is only a matter of time, and the man who neglects such facts in regulating his actions or conduct is rightly regarded as insane all the world over. The influence of micro-organisms on disease is emerging more and more, day by day, from the regions of uncertainty, and what once were the speculations of the few are now the accepted facts of the majority.

Miquel's experiments show very clearly that the number of microbes in the air corresponds with tolerable closeness to the density of population. From the Alpine solitudes of the Bernese Oberland to the crowded ward of a Parisian hospital, we have a constantly ascending ratio of microbes in the air, from zero to 28,000 per cubic metre. Their complete absence on the Alps is mainly due to the absence of productive foci. Organic matter capable of nourishing microbes is rare, and the dryness and cold prevent any manifestation of vitality or increase. Whence come the large number of microbes in the crowded places and in hospitals? Every individual, even in health, is a productive focus for microbes; they are found in the breath, and flourish luxuriantly in the mouth of those especially who are negligent in the use of the tooth brush. When we speak of "flourishing luxuriantly," what do we mean? Simply that these microbes, under favourable circumstances, increase by simple

division, and that one becomes about 16,000,000 in twenty-four hours. The breath, even of healthy persons, contains ammonia and organic matter which we can smell. When the moisture of the breath is condensed and collected it will putrefy. Every drop of condensed moisture that forms on the walls of a crowded room is potentially a productive focus for microbes. Every deposit of dirt on persons, clothing, or furniture, is also a productive focus, and production is fostered in close apartments by the warmth and moisture of the place. In hospitals productive foci are more numerous than in ordinary dwellings. If microbes are present in the breath of ordinary individuals, what can we expect in the breath of those whose lungs are rotten with tubercular disease? Then we have the collections of expectorated matter and of other organic secretions, which all serve as productive foci. Every wound and sore, when antiseptic precautions are not used, becomes a most active and dangerous focus, and every patient suffering from an infective disease is probably a focus for the production of infective particles. When we consider, also, that hospital wards are occupied day and night, and continuously for weeks, it is not to be wondered at that microbes are abundant therein. I want especially to dwell upon the fact that foci, and probably productive foci, may exist outside the body. It is highly probable, judging from the results of experiments, that every collection of putrescible matter is potentially a productive focus of microbes. The thought of a pit or sewer filled with excremental matters mixed with water, seething and bubbling in its dark warm atmosphere, and communicating directly (with or without the intervention of that treacherous machine called a trap) with a house, is enough to make one shudder, and the long bills of mortality already chargeable to this arrangement tell us that if we shudder we do not do so without cause. As an instance of the way in which dangers may work in unsuspected ways, I may mention the fact that Emmerich, in examining the soil beneath a ward of a hospital at Amberg, discovered therein the peculiar bacillus which causes pneumonia, and which had probably been the cause of an outbreak of pneumonia that had occurred in that very ward.

The importance of "Dutch cleanliness" in our houses, and the abolition of all collections of putrescible matter in and around our houses, is abundantly evident.

It will not be without profit to examine some well-known facts, by the aids of the additional light which has been thrown upon them by the study of the microbes which are in the media around us.

There is no better known cause of a high death-rate than overcrowding. Overcrowding increases the death-rate from infectious diseases, especially such as whooping cough, measles, scarlet fever, diphtheria, small-pox, and typhus. The infection of all these diseases is communicable through the air, and where there is overcrowding, the chance of being infected by infective particles, given off by the breath or skin, is of course very great. Where there is overcrowding, the collections of putrescible filth are multiplied, and with them probably the productive foci of infective particles. Tubercular disease, common sore throat, chicken-pox, and mumps, are also among the diseases which are increased by overcrowding.

To come to details which are more specific, let us consider the case of some diseases which are definitely caused by floating matter in the air. First, let us take one which is apparently attributable to pollen.

Hay-fever.

Among diseases which are undoubtedly caused by floating matter in the air, must be reckoned the well-known malady "hay-fever," which is a veritable scourge during the summer months to a certain per-centage of persons, who have, probably, a peculiarly sensitive organisation to begin with, and are, in a scientific sense, "irritable."

This disease has been most thoroughly and laboriously investigated by Mr. Charles Blackley, of Manchester, who, being himself a martyr to hay-fever, spent ten years in investigating the subject, and published the result in 1873, in a small work entitled "Experimental Researches on the Causes and Nature of *Catarrhus æstivus* (hay-fever or hay-asthma)."

Mr. Blackley had little difficulty in determining that the cause of his trouble was the pollen of grasses and flowers, and his investigations showed that the pollen of some plants was far more irritating than the pollen of others. The pollen of rye, for example, produced very severe symptoms of catarrh and asthma, when inhaled by the nose or mouth. Mr. Blackley came to the conclusion that the action of the pollen was partly chemical and partly mechanical, and that the full effect was not produced until the outer envelope burst

and allowed of the escape of the granular contents.

Having satisfied himself that pollen was capable of producing all the symptoms of hay-fever, Mr. Blackley next sought to determine, by a series of experiments, the quantity of pollen found floating in the atmosphere during the prevalence of hay-fever, and its relation to the intensity of the symptoms. The amount of pollen was determined by exposing slips of glass, each having an area of a square centimetre, and coated with a sticky mixture of glycerine, water, proof spirit, and a little carbolic acid. Mr. Blackley gives two tables, showing the average number of pollen grains collected in twenty-four hours on one square of glass, between May 28th and August 21st, in both a rural and an urban position. The maximum both in town and country was reached on June 28th, when in the town 105 pollen grains were deposited, and in the country 880 grains. The number of grains deposited was found to vary much, falling almost to zero during heavy rain, and rising to a maximum if the rain were followed by bright sunshine. Mr. Blackley found that the severity of his own symptoms closely corresponded to the number of pollen grains deposited on his glasses. Mr. Blackley also devised some very ingenious experiments to determine the number of grains floating in the air at different altitudes. The experiments were conducted by means of a kite, to which the slips of glass were attached, fixed in an ingenious apparatus, by means of which the surface of the glass was kept covered until a considerable altitude had been reached. Mr. Blackley's first experiment gave as a result that 104 pollen grains were deposited in the glass attached to the kite, while only 10 were deposited on a glass near the ground. This experiment was repeated. Again and again, and always with the same result, there was more pollen in the upper strata of the air than in the lower.

A very interesting experiment was performed at Filey, in June 1870. A breeze was blowing from the sea, and had been blowing for 12 or 15 hours. Mr. Blackley flew his kite to an elevation of 1,000 feet. The glass attached to the kite was exposed for three hours, and on it there were 80 grains of pollen, whereas a similar glass, exposed at the margin of the water, showed no pollen nor any organic form. Whence came this pollen collected on the upper glass? Probably from Holland or Denmark. Possibly from some point nearer the centre of Europe.

Potato Disease.

A study of the terrible disease which so often attacks the potato crop in this country will serve, I think, to bring forcibly before you certain untoward conditions which may be called climatic, and which are attributable to fungoid spores in the air.

With the potato disease you are all, probably, more or less practically acquainted. When summer is at its height, and when the gardeners and farmers are all looking anxiously to the progress of their crops, how often have we heard the congratulatory remark of "How well and strong those potatoes look." Such a remark is most common at the end of July or the beginning of August, when the green part, or haulm, of the plant is looking its best, and when the rows of potatoes, with their elegant rich foliage and bunches of blossom, have an appearance which would almost merit their admission to the flower border. The same evening, it may be, there comes a prolonged thunder storm, followed by a period of hot, close, moist, muggy weather. Four-and-twenty hours later, the hapless gardener notices that certain of his potato plants have dark spots upon some of their leaves. This, he knows too well, is the "plague spot," and if he examine his plants carefully he will perhaps find that there is scarcely a plant which is not spotted. If the thunder shower which we have imagined be followed by a long period of drought, the plague may be stayed and the potatoes saved; but if the damp weather continue, the number of spotted leaves among the potatoes increases day by day, until the spotted leaves are the majority; and then the haulm dies, gets slimy, and emits a characteristic odour; and it will be found that the tubers beneath the soil are but half developed, and impregnated with the disease to an extent which destroys their value.

Now the essential cause of the potato disease is perfectly well understood. It is parasitical, the parasite being a fungus, the *Peronospora infestans*, which grows at the expense of the leaves, stems, and tubers of the plant until it destroys their vitality. If a diseased potato leaf be examined with the naked eye, it will be seen that, on the upper surface, there is an irregular brownish black spot, and if the under surface of the leaf be looked at carefully, the brown spot is also visible, but it will

be seen to be covered with a very faint white bloom, due to the growth of the fungus from the microscopic openings or "stomata," which exist in large numbers on the under surface of most green leaves. The microscope shows this "bloom" to be due to the protrusion of the fungus in the manner stated, and on the free ends of the minute branches are developed tiny egg-shaped vessels, called "conidia," in which are developed countless "spores," each one of which is theoretically capable of infecting neighbouring plants.

Now it is right to say that, with respect to the mode of spread of the disease, scientific men are not quite agreed. All admit that it may be conveyed by contact, that one leaf may infect its neighbours, and that birds, flies, rabbits, and other ground game, may carry the disease from one plant to another and from one crop to another. This is insufficient to account for the sudden onset and the wide extent of potato "epidemics," which usually attack whole districts at "one fell swoop." Some of those best qualified to judge believe that the spores are carried through the air, and I am myself inclined to trust in the opinion expressed by Mr. William Carruthers, F.R.S., before the Select Committee on the Potato Crop in 1880. Mr. Carruthers' great scientific attainments, and his position as the head of the Botanical Department of the British Museum, and as the Consulting Naturalist of the Royal Agricultural Society, at least demand that his opinion should be received with the greatest respect and consideration. Mr. Carruthers said (Report on the Potato Crop, presented to the House of Commons, July 9, 1880, Question 143, *et seq.*):—

"The disease, I believe, did not exist at all in Europe before 1844. . . . Many diseases had been observed; many injuries to potatoes had been observed and carefully described before 1844; but this particular disease had not. It is due to a species of plant, and although that species is small, it is as easily separated from allied plants as species of flowering plants can be separated from each other. This plant was known in South America before it made its appearance in this country. It has been traced from South America to North America, and to Australia, and it made its first appearance in Europe, in Belgium, in 1844, and within a very few days after it appeared in Belgium it was noticed in the Isle of Wight, and then within almost a few hours after that it spread over the whole of the south of England and over Scotland. . . . When the disease begins to make its appearance the fungus produces these large oblong bodies (*conidia*), and the question is how these bodies are spread, and the disease scattered. . . . I believe that these bodies which are produced in immense quantities, and very speedily, within a very few hours after the disease attacks the potato, are floated in the atmosphere, and are easily transplanted by the wind all over the country. I believe this is the explanation of the spread of the disease in 1844, when it made its appearance in Belgium. The spores produced in myriads were brought over in the wind, and first attacked the potato crops in the Isle of Wight, and then spread over the south of England. The course of the disease is clearly traced from the south of England towards the midland counties, and all over the island, and into Scotland and Ireland. It was a progress northwards. . . . This plant, the *Peronospora infestans*, will only grow on the *Solanum tuberosum*, that is the cultivated potato. . . . Just as plants of higher organisation choose their soils, some growing in the water, and some on land, so the *Peronospora infestans* chooses its host plant; and its soil is this species the *Solanum tuberosum*. It will not grow if it falls on the leaves of the oak or the beech, or on grass, because that is not its soil, so to speak. Now the process of growth is simply this. When the conidia fall on the leaf, they remain there perfectly innocent and harmless unless they get a supply of water to enable them to germinate. . . . The disease makes its appearance in the end of July, or the beginning of August, when we have, generally, very hot weather. The temperature of the atmosphere is very high, and we have heavy showers of rain."

The warmth and moisture are, in fact, the conditions necessary for the germination of the conidia. Their contents (zoospores) are liberated, and quickly grow in the leaf, and soon permeate every tissue of the plant.

It was clearly established before the committee that not all potatoes were equally liable to the disease. The liability depends upon strength of constitution. It is well known that potatoes are usually, almost invariably, propagated by "sets," that is, by planting tubers, or portions of tubers, and this method of propagation is analogous to the propagation of other forms of plants by means of "cuttings." When potatoes are raised from seed, it is found that some of the "seedlings" present a strength of constitution which enables them to resist the disease for some years, even though the subsequent propagation of the seedling is entirely from "sets." The raising of seedling potatoes is a tedious process, but the patience of the grower is often rewarded by success, and I may allude to the fact that the so-called "Champion

potato," raised from seed in the first instance by Mr. Nicoll, in Forfarshire, and since propagated all over the country, has enjoyed, deservedly as it would appear, a great reputation as a disease-resisting potato; but all who have a practical knowledge of potato-growing seem agreed that we cannot expect its disease-resisting quality to last at most more than twenty years from its first introduction (in 1877), and that in time the constitution of the "Champions" will deteriorate, and it will become a prey to disease.

There is some evidence to show, also, that the constitution of the potato may be materially influenced by good or bad culture. Damp soils, insufficient or badly-selected manures, the selection of ill-developed potatoes for seed, and the overcrowding of the "sets" in the soil, all seem to act as causes which predispose the potatoes to the attacks of the parasite. Strong potatoes resist disease just as strong children will; while weak potatoes, equally with weak children, are liable to succumb to epidemic influences.

The following account of some exact experiments carried out by Mr. George Murray, of the Botanical Department of the British Museum, seems to show that Mr. Carruthers' theory as to the diffusion of conidia through the air is something more than a speculation:—

"In the middle of August, 1876," says Mr. Murray, "I instituted the following experiments, with the object of determining the mode of diffusion of the conidia of *Peronospora infestans*.

"The method of procedure was to expose on the lee side of a field of potatoes, of which only about 2 per cent. were diseased, ordinary microscopic slides, measuring 2 in. long by 1 in. broad, coated on the exposed surface with a thin layer of glycerine, to which objects alighting would adhere, and in which, if of the nature of conidia, they would be preserved. These slides were placed on the projecting stones of a dry stone wall which surrounded the field, and was at least five yards from the nearest potato plant. During the five days and nights of the experiment, a gentle wind blew, and the weather was, on the whole, dry and clear. Every morning, about nine o'clock, I placed fourteen slides on the lee side of the field, and every evening, about seven o'clock, I removed them, and placed others till the following morning at nine o'clock. The fourteen slides exposed during the day, when examined in the evening, showed (among other objects)—

"On the first day........	15	conidia.
,, second day	17	,,
,, third day	27	,,
,, fourth day......	4	,,
,, fifth day	9	,,

"On none of the five nights did a single conidium alight on the slides. This seemed to me to prove that during the day the conidia, through the dryness of the atmosphere and the shaking of the leaves, became detached and wafted by the air; while during the night the moisture (in the form of dew, and on one occasion of a slight and gently falling shower), prevented the drying of the conidia, and thus rendered them less easy of detachment.

"I determined the nature of the conidia—(1) by comparing them with authentic conidia directly removed from diseased plants; (2) by there being attached to some of them portions of the characteristic conidiaphores; and (3) by cultivating them in a moist chamber, the result of which was, that five conidia, not having been immersed in the glycerine, retained their vitality, which they showed by bursting and producing zoospores in the manner characteristic of *Peronospora infestans*."

Influenza.

Let us look at another disease by the light of recent knowledge, viz., the epidemic influenza, concerning which I remember hearing much talk, as a child, in 1847-48. There has been no epidemic of this disease in the British Isles since 1847, but we may judge of its serious nature from the computation of Peacock that, in London alone, 250,000 persons were stricken down with it in the space of a few days. It is characteristic of this disease that it invades a whole city, or even a whole country, at "one fell swoop," resembling in its sudden onset and its extent the potato disease which we have been considering. The mode of its spreading forbids us to attribute it, at least in any material degree, although it may be partially so, to contagion in the ordinary sense, *i.e.*, contagion passing from person to person along the lines of human intercourse. It forbids us also to look at community of water supply or food, or the peculiarities of soil, for the source of the disease virus. We look, naturally, to some atmospheric condition for the explanation. That the atmosphere is the source of the virus is made more likely from the fact that the disease has broken out on board ship in a remarkable way. In 1782, there was an epidemic, and on May 2nd, in that year, says Sir Thomas Watson—

"Admiral Kempenfelt sailed from Spithead with a squadron, of which the *Goliah* was one. The crew of that vessel were attacked with influenza on May 29th, and the rest were at different times affected; and so many of the men were rendered incapable of duty by this prevailing sickness, that the whole squadron was obliged to return into port about the

second week in June, not having had communication with any port, but having cruised solely between Brest and the Lizard. In the beginning of the same month another large squadron sailed, all in perfect health, under Lord Howe's command, for the Dutch coast. Towards the end of the month, just at the time, therefore, when the *Goliah* became full of the disease, it appeared in the *Rippon*, the *Princess Amelia*, and other ships of the last-mentioned fleet, although there had been no intercourse with the land."

Similar events were noticed during the epidemic of 1833—

"On April 3rd, 1833—the very day on which I saw the first two cases that I did see of influenza, all London being smitten with it on that and the following day—the *Stag* was coming up the Channel, and arrived at two o'clock off Berry Head on the coast of Devonshire, all on board being at that time well. In half an-hour afterwards, the breeze being easterly and blowing off the land, 40 men were down with the influenza, by six o'clock the number was increased to 60, and by two o'clock the next day to 160. On the self-same evening a regiment on duty at Portsmouth was in a perfectly healthy state, but by the next morning so many of the soldiers of the regiment were affected by the influenza that the garrison duty could not be performed by it."

After reviewing the various hypotheses which had been put forward to account for the disease, sudden thaws, fogs, particular winds, swarms of insects, electrical conditions, ozone, Sir Thomas Watson goes on to say:—

"Another hypothesis, more fanciful perhaps at first sight than these, yet quite as easily accommodated to the known facts of the distemper, attributes it to the presence of innumerable minute substances, endowed with vegetable or with animal life, and developed in unusual abundance under specific states of the atmosphere in which they float, and by which they are carried hither and thither."

This hypothesis has certainly more facts in support of it now than it had when Sir Thomas Watson gave utterance to it in 1837; and when another epidemic of influenza occurs, we may look with some confidence to having the hypothesis either refuted or confirmed by those engaged in the systematic study of atmospheric bacteria. Among curious facts in connection with influenza, quoted by Watson, is the following:—"During the raging of one epidemic, 300 women engaged in coal dredging at Newcastle and wading all day in the sea, escaped the complaint." Reading this, the mind naturally turns to Dr. Blackley's glass slide exposed on the shore at Filey, and upon which no pollen was deposited, while eighty pollen grains were deposited on a glass at a higher elevation.

SMALL-POX.

Let us next inquire into the evidence regarding the conveyence of small-pox through the air. In the supplement to the Tenth Report of the Local Government Board for 1880-81 (c. 3,290), is a report by Mr. W. H. Power on the influence of the Fulham Hospital (for small-pox) on the neighbourhood surrounding it. Mr. Power investigated the incidence of small-pox on the neighbourhood, both before and after the establishment of the hospital. He found that, in the year included between March, 1876, and March, 1877, before the establishment of the hospital, the incidence of small-pox on houses in Chelsea, Fulham, and Kensington amounted to 0·41 per cent. (*i.e.*, that one house out of every 244 was attacked by small-pox in the ordinary way), and that the area enclosed by a circle having a radius of one mile round the spot where the hospital was subsequently established (called in the report the "special area"), was, as a matter of fact, rather more free from small-pox than the rest of the disrict. After the establishment of the hospital in March, 1877, the amount of small-pox in the "special area" round the hospital very notably increased, as is shown by the Table by Mr. Power, given on p. 907.

This Table shows conclusively that the houses nearest the hospital were in the greatest danger of small-pox. It might naturally be supposed that the excessive incidence of the disease upon the houses nearest to the hospital was due to business traffic between the hospital and the dwellers in the neighbourhood, and Mr. Power admits that he started on his investigation with this belief, but with the prosecution of his work he found such a theory untenable.

Now the source of infection in cases of small-pox is often more easy to find than in cases of some other forms of infectious disease, and mainly for two reasons:—

1. That the onset of small-pox is usually sudden and striking, such as is not likely to escape observation.

2. That the so-called incubative period is very definite and regular, being just a fortnight from infection to eruption.

The old experiments of inoculation practised on our forefathers have taught us that from

ADMISSIONS OF ACUTE SMALL-POX TO FULHAM HOSPITAL, AND INCIDENCE OF SMALL-POX UPON HOUSES IN SEVERAL DIVISIONS OF THE SPECIAL AREA DURING FIVE EPIDEMIC PERIODS.

Cases of acute small-pox.	The epidemic periods since opening of hospital.	Incidence on every 100 Houses within the Special Area and its Divisions.				
		On total special area.	On small circle, 0-¼ mile.	On first ring, ¼-½ mile.	On second ring, ½-¾ mile.	On third ring, ¾-1 mile.
327	March-December, 1877	1·10	3·47	1·37	1·27	·36
714	Jannary-September, 1878	1·80	4·62	2·55	1·84	·67
679	September, 1878–October, 1879..	1·68	4·40	2·63	1·49	·64
292	October, 1879–December, 1880 ..	·58	1·85	1·06	·30	·28
515	December, 1880–April, 1881	1·21	2·00	1·54	1·25	·61
2,527	Five periods	6·37	16·34	9·15	6·15	2·56

inoculation to the first appearance of the rash is just twelve days. Given a case of small-pox, then one has only to go carefully over the doings and movements of the patient on the days about a fortnight preceding, in order to succeed very often in finding the source of infection.

In the fortnight ending February 5th, 1881, forty-one houses were attacked by small-pox in the special mile circle round the hospital, and in this limited outbreak it was found, as previously, that the severity of incidence bore an exact inverse proportion to the distance from the hospital.

The greater part of these were attacked in the five days, January 26-30, 1881, and in seeking for the source of infection of these cases, special attention was directed to the time, about a fortnight previous, viz., January 12-17, 1881. The comings and goings of all who had been directly connected with the hospital (ambulances, visitors, patients, staff, nurses, &c.) were especially inquired into, but with an almost negative result, and Mr. Power was reluctantly forced to the conclusion that small-pox poison had been disseminated through the air.

During the period when the infection did spread, the atmospheric conditions were such as would be likely to favour the dissemination of particulate matter. Mr. Power says:—"Familiar illustration of that conveyance of particulate matter, which I am here including in the term dissemination, is seen, summer and winter, in the movements of particles forming mist and fog. The chief of these are, of course, water particles; but these carry gently about with them, in an unaltered form, other matters that have been suspended in the atmosphere, and these other matters, during the almost absolute stillness attending the formation of dew and hoar frost, sink earthwards, and may often be recognised after their deposit. As to the capacity of fogs to this end, no Londoner needs instruction; and few persons can have failed to notice the immense distances that odours will travel on the 'air-breaths' of a still summer night. And there are reasons which require us to believe particulate matter to be more easy of suspension in an unchanged form during any remarkable calmness of atmosphere. Even quite conspicuous objects, such as cobwebs, may be held up in the air under such conditions. Probably there are few observant persons of rural habits who cannot call to mind one or another still autumn morning, when from a cloudless, though perhaps hazy, sky, they have noted, over a wide area, steady descent of countless spider-webs, many of them well-nigh perfect in all details of their construction."

A reference to the meteorological returns issued by the Registrar-General, shows that on the 12th of January, 1881, began a period of severe frost, characterised by still, sometimes foggy, weather, with occasional light airs from nearly all points of the compass. This state of affairs continued till January 18, when there was a notable snowstorm, and a gale from the E.N.E. For four days, up to and inclusive of January 8, ozone was present in more than its usual amounts. During January 9—16, it was absent. On January 17, it reappeared; and on January 18, it was abundant. Similar meteorological conditions

(calm and no ozone) were found to precede previous epidemics.

Mr. Power's report, with regard to Fulham, seems conclusive, and there is a strong impression that hospitals, other than Fulham, have served as centres of dissemination.

In the last lecture I gave you the opinion of M. Bertillon, of Paris, and quoted figures in support of that opinion. It is a fact of some importance to remember that small-pox is one of those diseases which has a peculiar odour, recognisable by the expert. As to its conveyance for long distances through the air, there are some curious facts quoted by Professor Waterhouse, of Cambridge, Massachusetts, in a letter addressed to Dr. Haygarth at the close of the last century. Professor Waterhouse states that at Boston there was a small-pox hospital on one side of a river, and opposite it, 1,500 yards away, was a dockyard, where, on a certain misty, foggy day, with light airs just moving in a direction from the hospital to the dockyard, ten men were working. Twelve days later all but two of these men were down with small-pox, and the only possible source of infection was the hospital across the river.

(*To be continued.*)

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The number of visitors to the Exhibition for the week ending Tuesday, 7th inst., was 160,458. Total since the opening, 1,475,932.

INTERNATIONAL CONGRESS ON INTERNAL NAVIGATION.

The first Congress on Internal Navigation was held in the Palais des Académies, Brussels, during the week ending 30th May, under the patronage of the Belgian Government, and the honorary presidency of the Minister of Agriculture, Industry, and Public Works, who observed, in his opening speech, that public attention was now being directed to waterways, not with that impetuosity which, fifty years ago, led to the rapid creation of an immense iron network, but with a wise prudence which argued well for their future. It was now acknowledged that canals had been too long neglected, and that, established for the most part without interconnection, they had but slightly contributed to the progress which had been made in every branch of industry. Railways, however powerful, could no longer monopolise the carrying trade; but canals were capable of great improvement—their formation, the vehicle carried by them, the motive power, &c., varying greatly even in a single country.

M. Léon Somzée, civil engineer and representative in the Chamber for Brussels, was elected President of the Congress, with M. Weinmann as Vice-President, and Messrs. Cavens, Cossoux, De Blois, and Van Drunen as secretaries.

M. Dirks, engineer to the Dutch Waterstaat, and member of the Suez Canal International Commission, read a paper on the best method of keeping up the banks of canals, with a view to working them at high speed. He mentioned incidentally that the unanimous conclusions arrived at by the above-named Commission were that the Suez Canal should be widened and dredged to a depth of 9 metres, or nearly 30 feet, below low water of ordinary spring tides, though a deepening of 8·5 metres would be sufficient for the present. With the banks protected in the manner recommended, a speed of probably 8 knots an hour would be attained, so that vessels could pass through in half the time now occupied.

Signor Di Gioia, delegate of the Italian Government, and also member of the Suez Canal International Commission, said that the most economical method of keeping up the banks of that canal was to plant them where possible, and that the date palm answered admirably for that purpose; but, where this could not be done, the banks should be pitched in accordance with a method approved of by the Commission, in which case steamers might pass through in ten instead of, as now, twenty-four hours. He subsequently presented the Congress with a detailed description of the water ways of Italy.

M. A. Casse observed that the *débris* from excavating a canal were carried off most economically by water, which did not wear out like mechanical combinations, and that there should be as little intermediary mechanism as possible. In an excavator of his own invention, in which a jib carries a revolving cutter giving blows like those of a pickaxe, the *débris* were drawn through the hollow jib by an exhausting fan, and deposited upon the banks, with a saving of 50 per cent. as compared with the ordinary dredge.

M. Fleury, civil engineer, of Paris, thought the excavator described by M. Casse would not serve for soils of more than 3 or 3½ specific gravity. Dredges with long tubes, which were exclusively used for the Suez Canal, constituted the most economical system when the excavated earth could be delivered on the banks.

M. Tcharnomsky, civil engineer of St. Petersburg, gave some particulars of the recently opened Petersburg and Cronstadt Canal, which would render unnecessary the transhipment of goods, whereby a loss of £800,000 per annum has hitherto been

incurred on a traffic of 2,700,000 tons. The canal was seventeen miles long and 22 feet deep; while the Goutonieff dock, with two supplementary basins, had an area of 430 acres. The foundations of the quay walls were formed of fir-log caissons, well tied together and always under water, filled with pebbles and surmounted by a layer of concrete, on which was built the masonry wall.

Herr Düsing, Engineer-in-Chief for the Canalisation of the Main, contributed some particulars of that work, to be completed by 1st October, 1886, which will permit of the largest vessels that navigate the Rhine ascending the Main as far as Frankfort. The depth of that river was to be increased to 6 ft. 6 in., while the locks were designed for an eventual depth of 8 ft.

Herr Stahl, delegate of the Frankfort Municipality, described the works begun last year (in connection with the above) for the formation of an internal port at Frankfort, designed by Mr. Lindley, engineer-in-chief of that city. The intention was to reconcile the conditions of facility in mercantile transactions with the greatest economy in transhipment from vessels to railway waggons, and *vice versâ*.

Mr. Huet, engineer, of Delft, spoke as to the best motive power for working canals, and described his "water locomotive," which had a series of plain cylinders under the keel driven by endless band from a steam-engine, and with which experiments on a small scale had led him to hope for as high a speed on canals as was now attained on railways.

Mr. E. Leader Williams described the works required in the construction of the Manchester Ship Canal, in the course of which he observed that it had, on mature reflection, been decided to use locks, because, even if the canal were cut at great expense on a single level, that of the sea, it would be necessary to raise the goods to the height of the inland port, and there were no means of doing this so cheaply as by ship-load in the lock.

Mr. Daniel Adamson, chairman of the Manchester Ship Canal Company, followed with some economical considerations connected with that scheme. He said that the first inception of the project was due to the fact that cotton imported from India into London cost less for ship transit over 4,000 miles than the railway journey of 200 miles from London to Manchester; while manufactured goods sent by through rate from Manchester to Bombay cost 12s. 6d. for the forty miles by rail to Liverpool, and only 10s. for the remaining 4,000 miles. The Manchester manufacturers were only trying to get a cheaper route for their raw materials and finished products, as well as for their breadstuffs, for now, instead of carrying 3,000 tons of grain in bulk directly to Manchester in one steamship, it was necessary to unload the grain on the quay, reload it into 1,500 carts or trucks, transfer it to 1,000 railway waggons of 3 tons each, send it to Manchester by rail, and then unload again. Water-carriage was the carriage of the future for heavy and not necessarily fast traffic, the legitimate province of the railways, with their handmaids, the telegraph and the telephone, being for quick speed and light weight; while railways and canals should work together, each carrying its own appropriate class of goods. Railway companies should be content with carrying passengers, 14 to the ton, at 14d. a mile, instead of heavy goods at 1d. a mile, with loading at one end, and unloading at the other. The great impetus given to trade by internal navigation must necessarily bring in its wake a vast accession of passenger traffic, so that railways would, in the long run, be benefited rather than the reverse by the making of ship canals where required. No carriage was so cheap as water-carriage, by which goods might be conveyed at one-tenth to one-hundredth the cost by rail.

Mr. Mulvany, of Frankfort, formerly Commissioner of Public Works in Ireland, remarked that oceans were the highways of the world, and that one of the principal objects of the Congress should be to extend the benefits of cheap freight as far into the interior as possible. Nor did he believe that, in the long run, Antwerp and Liverpool would suffer through Brussels and Manchester being made seaports.

M. de Maere Limnander, President of the Cercle Bruges Port-de-Mer, gave some particulars of the project for again making a seaport of Bruges, which, in the middle ages, was the principal emporium of Europe, but had lost that proud position through the silting up of the Zwyn, an arm of the Scheldt estuary. He proposed to cut a ship canal $7\frac{1}{2}$ miles long, 66 feet wide, and 24 feet deep, between Bruges and a point on the sea coast between Heyst and Blankenberghe, where would be a deep-sea harbour, so that vessels from 3,000 to 4,000 tons burden could enter at any state of the tide. A proposition by an English syndicate to carry out the works was then under consideration by the Belgian Government.

Professor Schlichting, of the Berlin Polytechnicum, contributed some particulars of the projected canalisation of the Weser, to admit of large vessels penetrating into the interior of Germany.

M. de Saint-Hubert, of Namur, spoke in favour of making the canals of different countries as uniform as possible, and organising them into a regular system like the railways, while providing them with the telegraph. To permit of their being navigated by night as well as by day, he would utilise the fall of water over the weirs for generating electric current, to illuminate the banks and locks. He then gave an outline of his scheme for uniting all the large rivers of Central Europe, so as to make Berlin and Vienna seaports.

Herr Lauenroth, Regierungs-Baumeister of Münster, referred to the project, which was now definitely decided upon and would soon be carried into execution, of making a system of canals in Westphalia, which would put the collieries of the Ruhr district in communication with all the water ways of Germany.

M. Strauss, delegate from the City of Antwerp,

spoke entirely from the standpoint of that port, which bears the same relation to Brussels (as a seaport) that Liverpool does to Manchester with its ship canal. In projecting a ship canal, the constantly increasing dimensions of sea-going ships should be taken into account. The large canals of France had not driven away trade from existing harbours; and their examples were no guide for Brussels, Manchester and Vienna, which lay under totally different conditions. The advocates of ship canals had neglected some important factors, such as facilities for loading and unloading, the state of markets and return freights.

M. Colson, engineer, of Ghent, showed that the projected Brabant canals could be supplied with water without drawing from the Scheldt, and gave a summary of the conclusions arrived at by the Commission appointed to examine the question.

Dr. Von Stüdnitz, of Bremen, quoted some comparative statistics of land and water carriage, and advocated the adoption of the same basis of classification in both cases, so as to facilitate comparison.

M. Stieltjes, engineer, of The Hague, gave some particulars of the Dutch canals, originally cut for drainage, but appropriated to navigation since 1815. They had been neglected after the first railways were made; but, in 1878, it was found necessary to improve them and to dredge the beds of rivers. In 1881, Dutch imports amounted to 10,300,000 tons, three parts of which came by water, and the exports to 4,700,000 tons, of which 70 per cent. were forwarded by canal, the Rhine, and the Scheldt. There were on the canals no less than 217 steam-boat services, the speed varying from five to ten miles an hour; and the number of passengers was continually increasing.

M. Braun, of Ghent, contributed some details as to the shore arrangements to be carried out at that port. The warehouses would have cellars and an upper storey; while between them and the quay wall would be a double line of way for the railway waggons and hydraulic cranes, and at their back four lines of way, one of them under cover.

The Marquis de Caligny described his arrangement of lock for effecting a saving of water, and avoiding shocks in filling and emptying, by taking part of the water from the lower reach in filling, and raising a portion to the upper reach in emptying. This automatic system, put in action by one man, was applied to the Aubois lock of the Loire Canal; and the trials showed a saving of four-fifths the water.

M. Jules de Blois, architect, of Brussels, and one of the secretaries of the Congress, brought forward statistics to prove that the value of property in Brussels had diminished from 50 to 100 per cent., while that in Antwerp had increased in the same proportion. This he attributed to the impulse given to trade by the harbour works at Antwerp, claiming a ship canal to Brussels—which was in about the same case as Manchester—in order to restore the equilibrium.

The following are among the conclusions arrived at by the various sections:—Canal tolls should be lowered, but not abolished, as free right of way would interfere with private enterprise. All the canal locks of a country should be of uniform type. The conditions under which a ship canal would repay its cost could only be determined in each individual case according to the probable traffic and the state of the markets. Dredges or excavators are the best appliances for cutting canals. Caissons, modified to suit the nature of the soil, and, when very loose, piles, are the best means for forming dock and quay walls. The several governments should undertake trials for ascertaining the best mode of traction on canals. Ordinary locks possess great advantages on account of their simplicity; and mechanical means should only be resorted to when there is a considerable difference of level. The amount of each lift should be determined by the nature of the ground and the supply of water; and twin locks were useful when vessels of various sizes were employed.

A standing committee was formed, with M. Léon Somzée as president, to carry on the work of the Congress, which is to re-assemble next year at Vienna, on the invitation of the municipal authorities.

Excursions were made to Bruges, to see the site of the proposed canal to connect it with the sea, and then on the Bruges and Ostend canal; to Antwerp by the Willebroeck canal, the Rupel and the Scheldt; to Ghent, and then to Terneuzen by canal, and up the Scheldt; to Mechlin, and thence to Louvain by the canal projected in the reign of Marie Therèse; and, lastly, up the canalised Meuse from Liége to Givet, just across the French frontier, including a visit to the Cockerill works at Seraing, which employ 11,000 hands.

ACCLIMATION OF TREES YIELDING INDIA-RUBBER AND GUTTA-PERCHA.

By James Collins.

The care and oversight of forests is now generally recognised and accepted as a State duty, beyond the limits and capabilities of private individuals. Such duties consist in the protection of trees from reckless destruction, replanting denuded portions, and introducing useful plants from their natural habitats to other localities having isomeric conditions of heat and moisture, and where such introduced plants are likely to prove of general utility. This latter operation is known as acclimation. The constitution of plants is a subject of great interest, and has to be considered with great judgment and abundance of information; plants have certain limited ranges, and such ranges of heat and moisture have to be clearly defined, for by no process of acclimation can a plant be made to tolerate a degree more or less than its proper limit, except to its detriment. If they be subjected to conditions other than their natural ones,

they either die or become so modified as to fail to develop those special features of structure, habit or constituents, which are their characteristics in their native habitat. A single instance may be quoted here, by way of example, to show how a plant may be altered by different climatic influences. In Europe for ages the common hemp (*Cannabis sativa*, L.), has been cultivated for its fibre and oily seeds,* whilst in India the same plant shows a wide dissimilarity, especially in its medicinal characteristics, its leaves, flowering and fruiting stalks yielding a resin and volatile oil, known under various names as bhang, dhurrus, ganga, &c., having powerful narcotic properties, the resin being apparently formed at the expense of the fibre, as the stalks are usually burnt as useless.†

The ascertainment of the extremes and mean annual temperature and moisture which best suit certain plants is the result of experiment, and is sometimes surrounded with so much difficulty that frequently trials should be made simultaneously, in two or more localities judged to possess similar climatic conditions.

All these experiments entail expense, especially in the case of those trees the utilisable portion of which consists of timber, milky juices, &c., which require a period of ten to thirty years or more to elapse after planting before they come to maturity, or any return can be expected on the initial expenditure and up-keep. This outlay, together with the long delayed returns, even if the experiment be finally crowned with success, naturally will and must fail in procuring the accomplishment of such trials by private enterprise. Government must at least give its aid in the initiation of such schemes.

In the case of the cinchonas the Indian Government did, with rare forethought, listen to such men as Pereira, Howard, and Markham, and undertook the initiative; and as soon as the experiment proved successful, private planters at once showed their willingness to expend their money in the same undertaking. So has it proved in a minor degree in the present instance.

Another fact is also worthy of remembrance, namely, that acclimated trees invariably improve, and their products, from the care and attention paid in their preparation, acquire a much higher value than spontaneous or uncared-for produce. As instances, mention may be made of the much higher per-centage of quinine yielded in India from cultivated trees than from those of South America; and also that a specimen of Assam rubber, prepared according to my suggestions (I think by the late Mr. Leeds) was valued by one of the highest authorities in London, Mr. Edward Till, of the firm of Messrs. Jackson and Till, at from 8d. to 10d. per pound more than ordinary Assam rubber.*

Fortunately, with respect to the special question of gutta-percha trees, some of these difficulties do not exist. There, in their natural habitats, and in territory, too, under Imperial rule and influence, are numbers of these trees ready for conservancy and cultivation, and where nurseries of plants can be started for acclimation elsewhere. Although some twenty-five years will have to elapse after planting before the trees are ready for tapping or the axe, yet, in the interim, a revenue could be secured, to pay working expenses at least, from the trees already existing, by "farming" them, or by royalties on the out-turn. A stringent rule in all such contracts should be that four to six trees should be planted in place of every one cut down.

As to what species should be cultivated on the spot, or to be introduced, gutta-taban, gutta-durian, gutta-waringan, gutta-kalapeieh, and gutta-mukas, stand in the front. Many others, although passing under other designations, may prove equally valuable.

Amongst pseudo gutta-perchas, or substitutes recommended as supplementary to the true gutta, I would certainly single out the balata gum (*Mimusops balata*, Gaertner), as it would prove a most valuable addition to our trade supplies. As to the Indian varieties of this group, I would strongly recommend that the pauchontee should receive careful attention, and its product collected and prepared in proper manner. Such specimens so prepared would then allow of the question being, probably, set at rest. I have not much hopes of cattimandoo, mudah, and some other substances, but other uses might be found for them if good samples and guaranteed qualities were available.

As to the climatic conditions necessary for the cultivation of gutta-percha trees, Borneo, Labuan, Sarawak, Singapore, and, more especially, the Southern States of the Malayan Peninsula, being the natural home of these trees, present the first localities in which cultivation should be essayed. Ceylon, like some localities in Assam, and, possibly, the Nicobar islands, would form a congenial home for these plants.

On the whole question of india-rubber, gutta-percha, and pseudo-guttas, there is much still to be learned. There may be yet many improvements to be made in the collection and preparation, but these facts can only be gleaned by one somewhat conversant with market and manufacturing requirements,

* The great dissimilarity between the European species led Lamarck to consider the latter a distinct one, and designated it *Cannabis Indica*, but it is now agreed that no specific difference exists between them.

† Why burn the stalks of the Indian hemp? Why not utilise them? I have suggested to several planters that they might make capital paper material, especially if sent over here as "half-stuff."

* In a paper on India-rubber, delivered at the Society of Arts (*Journal of the Society of Arts*, December 17th, 1869), and again in my report on the same subject to the Indian Government in 1872, I strongly recommended the cultivation of the native *Ficus elastica*, and the acclimation of the *Hevea Brasiliensis*, yielding Para rubber, and also other species from which are obtained valuable commercial varieties. Backed as I was by Mr. Clements R. Markham C.B., and Mr. Gustav Mann, of the Indian Forest Department, the Indian Government took the matter in hand.

added to some amount of botanical and chemical knowledge. Such a task undertaken on the spot, if well executed, would clear up many a doubtful point, and render great and lasting service to commerce and science.

AGRICULTURE IN CHILI.

Consul Dunn, of Valparaiso, states that agriculture generally is in a very backward condition in Chili, and though there are some large estates belonging to wealthy owners, which in any country would be considered as "model farms," they form the exception to the general rule. The implements used by the Chilian farmer consist of a plough, which is nothing more than a pointed stick, sometimes shod with iron and sometimes not, with which the ground is scratched, not even being turned up, and a bundle of bushes is used as a harrow. The seed is sown by hand, and much seed is wasted. Reaping is done with sickles, and the threshing is performed in the open air by horses, which are made to gallop round in a circle on the cut grain, and thus tread out the corn. The winnowing is done by throwing the grain in the air against the wind. With this system of threshing and winnowing, the grain finds its way to market in a very dirty condition, the per-centage of pulverised earth alone being from two to four pounds for every hundred pounds of wheat or barley. Besides wheat and barley, maize and beans are cultivated, but rye and oats are almost unknown. Linseed, hemp seed, canary seed, and rape seed are also produced, but the two first only form articles of export and on a limited scale. Tobacco is largely cultivated for home consumption. The average yield of wheat appears to be at the rate of about 190 lbs. per acre. The annual production of wheat is estimated at about 9,000,000, and other cereals at 3,000,000 cwts. The annual wine production is estimated at 14,000,000 gallons. The only public lands, properly so called, remaining, are those existing in Arauco. The district is being opened by railways and the land is to be disposed of, but the probabilities are that the greater portion of it will fall into the hands of a few wealthy persons. Consul Dunn states that an eminent public man has lately given it as his opinion that Chili could not produce a food supply for a population of more than 15,000,000. In lieu of the old system of tithes, a land tax is now levied at the rate of 2 per cent. upon the assessed rental of the land. The revenue for roads and schools is provided by the State, and tolls which are farmed are levied on the farmers. The price of labour in Chili varies very considerably according to the district. In the extreme south the wages of the agricultural labourer do not exceed 5d. a day, while in the north they rise until they reach 1s. 3d. with food, which consists almost exclusively of beans and coarse bread.

General Notes.

Combination of German Jute Manufacturers.—The Berlin *Börsen-Courier* states that, in view of the decreasing prices of jute goods, the German manufacturers of these products have decided upon forming a syndicate which will fix minimum prices for various articles, under which rates no member will be allowed to sell.

Utilisation of Smoke.—At the collieries of Elk Rapid, U.S., the smoke from twenty-five furnaces is utilised for the manufacture of chemical products. It is collected in a wooden main pipe leading to a fan by which it is driven to a condensing and cleaning apparatus. The products obtained are meth. alcohol, tar, illuminating gas, and pyroligneous acid, which are used for making acetate of lime. The 79,296 cubic metres of smoke treated daily produce 5,411 kilogrammes of acetate of lime, 908 litres meth. alcohol, and a large quantity of tar.

Relative Cost of Spinning in France and England.—The Amiens Chamber of Commerce recently deputed one of its members to represent to the Commission for examining the question of temporary admission, various facts in support of the views entertained by French spinners upon this point. Amongst the arguments brought forward was the fact that since the cession of Alsace and Lorraine to Germany, French spinners are tributaries of England for their machinery. Moreover the average cost of a cotton spindle in France is 40s. to 60s., according to the numbers spun, and the extent of preparatory treatment. In England the cost is about 20s., while the dividends paid are often higher than in France.

Drill of the London School Board Boys.—The annual contest between schools of the London School Board in drill was held in competition for the banner presented by the Society of Arts, on Saturday, 11th inst., in the grounds of Lambeth Palace. There were twelve companies, each of twenty files, with captain and supernumeraries, and the whole body represented eleven schools, one having two companies. Lord Brabazon acted as judge, and the drill was witnessed by Sir Robert Rawlinson, C.B., Mr. Edwin Chadwick, C.B. (vice-presidents of the Society of Arts), and several members of the School Board, and Mr. H. Croad, the chief clerk. There was a long drill, and it was only after some time, and trying companies again and again, that Lord Brabazon awarded the banner to the Berwick-street Soho school, the winners of last year, and said he had had a difficult task in deciding between that school and Farrance-road Limehouse school. The banner was presented, and praise was given to the schools mentioned and to the boys of Bellenden-road Peckham school.

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Proceedings of the Society.

CANTOR LECTURES.

CLIMATE IN ITS RELATION TO HEALTH.

By G. V. Poore, M.D.

Lecture III.—Delivered January 26, 1885.

Diseases caused by Floating Matter in the Air. Malaria. Mountain Climate. Conclusion.

(Continued from p. 908.)

Phthisis.

There is no disease with which we are more familiar than tubercular disease of the lungs—consumption, or phthisis, as it has been called. It is a disease which has been the opprobium of medicine, and which, when well established, is rarely recovered from. The views as to the nature of the changes which take place in the lungs have been almost as varied as the writers have been numerous. And it is only within the last few years that we have arrived at anything like a fixed opinion as to the nature of the disease. This advance has been due to Koch, the eminent physician and sanitarian of Berlin, who seems to have proved that there is always to be found in association with tubercular disease a micro-organism, which he has called the *Bacillus tuberculosis*. There is no doubt about the bacillus. Koch having shown the way, we none of us have any difficulty in finding it. It is not present in those forms of lung disease which are not tubercular, but it is invariably associated with tubercle wherever found, and it is easily detected in the matter coughed up by consumptive patients.

It has long been known that tubercular disease is infective, *i.e.*, that a localised focus of the disease in any part of the body might infect the whole body, and it has been lately shown that the disease is definitely inoculable, and that the *Bacillus tuberculosis* is probably its true cause.

Is the *Bacillus tuberculosis* a fact or a fancy? The importance of settling this question cannot be over-estimated, for if it be proved that the bacillus is the actual cause of tubercular disease, that consumption is, so to say, a zymotic, our attitude towards the disease in the future will be very different from what it was in the past.

The arguments in favour of the bacillary cause of tubercle seem to me to be as strong as they can well be, and it is a noteworthy fact that the acceptance of the theory by physicians and pathologists in this country becomes daily more and more general.

I think it will be conceded also that many of the well-known facts regarding phthisis are more in accord with its being an infective than a local inflammatory disorder.

That a local tubercular deposit will infect the whole body much in the way that a foul wound will sometimes infect the whole body is well-known, and arguing by analogy, this is a strong reason in favour of phthisis being an infective disease dependent on the growth of an organism.

When once tubercular disease is established, it is not often recovered from. A man contracts phthisis from working in an ill-ventilated crowded workshop. After the disease is fully established the chance of stopping it is small, notwithstanding that he be removed from the conditions which caused his trouble. If the case were due to the chemical or mechanical foulness of the air starting inflammatory action, then the disease should stop when the cause is removed. If, on the other hand, bacilli have found a home in the lungs, they would probably continue to grow after their growth had been once started. The persistence of the disease when once it gets a hold, seems to be an argument in favour of its being caused by the growth of an infecting organism.

We are still in doubt as to whether tubercle is infectious in the ordinary sense, and cases of the disease having passed from person to person by "infection" are so rare as to leave us in doubt whether some error may not have

vitiated the recorded case. On the other hand, it must be borne in mind that the onset of tuberculosis is very insidious and gradual, and is not attended with any striking phenomena like the onset of the eruptive fevers, so that the time of onset can never be determined. And, again, the disease is so common that when tubercle makes its appearance we can never say that the individual infected by it has not been exposed to infection.

Its undoubted relationship to overcrowding and bad ventilation seems to me a very strong argument in favour of its infective nature. Phthisis causes rather more than 10 per cent. of deaths in this country, and is by far the commonest of any cause of death. In any workshop where a considerable number of artisans are working together, it is highly improbable that there are not some who are in a state to infect others; and if the cubic space be small and the ventilation bad, the risks of infection are greatly increased.

The *Bacillus tuberculosis* is one of those which readily form spores, which are to the bacillus itself very much what the seed of a plant is to a cutting. We know that seeds may be kept for very long periods without losing their power of germinating. In this the spore of the *Bacillus tuberculosis* resembles a seed. It may be dried and lie dormant for a long time, but being raised with the dust of the room, and being inhaled into the lungs, we have every reason to think that such a spore is capable of infecting the individual who is unfortunate enough to inhale it. The bacilli can be cultivated outside the body, but they require a high temperature equal to that of the blood (*i.e.*, 98° and upwards to about 103° Fahr.), so that we cannot assume that in this country there is any spontaneous growth of tubercle bacilli outside the body.

Dr. George Buchanan has shown that the death-rate from tubercular disease has sensibly decreased in certain localities, where effectual sewerage works have been carried out. Why there should be this connection between sewerage and pulmonary consumption is not clear. The sewerage works, by removing filth from the neighbourhood of dwellings, would be likely to improve the health of the dwellers and increase their power of resisting infection.

Again, a certain amount of definitely dangerous and infective matter coughed up from diseased lungs would find its way into the sewers, and thus be carried clean away from the neighbourhood of the dwelling. The soil being made drier, and the air as a consequence of this drier also, the bacilli would be more likely to lose their vitality, although the spores would not be affected.

A putrid soil, or a putrefying cesspool, although they would not probably serve as a cultivation medium for the *Bacillus tuberculosis*, may serve to maintain their vitality and virulence.

Whatever may be the true explanation of the fact which has been pointed out by Dr. Buchanan, we shall all readily admit that tuberculosis does not stand alone as an instance of an infective disease, the deadliness of which is enhanced by filthy surroundings.

There is one fact in connection with tuberculosis which is difficult to explain by the theory of infection, and that is its undoubted hereditariness, for that it is a disease which runs in families in a remarkable way there can be no doubt. There is, it must be remembered, more than one infective disease which is communicated by the parent to the offspring, but that this is often the case in tuberculosis is rendered unlikely by the fact that the disease does not often show itself till some years after birth.

When dealing with Raulin's experiment, at the close of the last lecture, the experiment which showed the importance of almost infinitesimal ingredients in cultivating media, I took occasion to remark that a constitutional predisposition to this or that disease, such as scarlatina or tuberculosis, might mean that the blood and tissues contained some infinitesimal ingredient necessary for the growth of the organism which gave rise to the disease.

Again, may not the predisposition to consumption consist in the inheritance of a long narrow chest, which is the typical characteristic of a consumptive race? The coughing power, and the power of the lung to expel catarrhal products, is below par in such persons, and this is especially the case at the apex, which is the seat of election for the commencement of tubercular disease. The secretions of the lung lodging at this point would serve as a fitting nidus for the growth of the bacillus. Given a person whose family history points to a predisposition to consumption, it has always seemed to me, speaking as the medical officer of a life insurance office, that in estimating the probability of the individual suffering from consumption, the point of most importance to look to is the shape of the chest.

I have gone rather fully into some of these details, because of the general belief that

phthisis is a disease inseparable from certain climates, especially climates like our own, which are cold and damp. It will appear, however, that it is rather an accident, so to say, attendant upon living in such a climate; a climate which induces us to live in overcrowded dwellings, and to neglect the important considerations of cubic space and ventilation.

The following facts, culled from the works of Dr. Parkes and Professor de Chaumont, are not without interest.

The large death-rate in the country from diseases of the respiratory organs Professor de Chaumont believes to be due to the breathing of impure air, a cause which affects all classes of the community—high, low, rich, or poor; and he gives an interesting diagram of the death-rate from these diseases in the registration districts north of the Thames, which shows tolerably conclusively that the death-rate is proportionate to the crowding, and also to the population gathered round any particular spot. That is to say, that overcrowding under all circumstances is a cause of respiratory disease, but that overcrowding in a large town is more harmful than in a comparatively small one.

During the years 1830-46, the mean mortality from phthisis in the army on home service amounted to 7·86 per 1,000 of strength, the highest mortality being among the Foot Guards, with whom it reached 11·35 per 1,000 of strength. This state of things attracted the attention of Sir Alexander Tulloch and Dr. Balfour, who pointed out that, in the Equitable Assurance Company at that time, the average mortality between the ages of 30 and 40, from all diseases of the lungs, amounted to 3·4 per 1,000. The army mortality from phthisis was, therefore, three times greater than necessary.

The large mortality from phthisis among this picked class of the population, a class picked for their high physical qualities, and leading a life which at first sight would seem typically healthy, naturally roused inquiry as to the cause.

That it was not due to climatic conditions seemed tolerably plain, for the mortality of our troops from the same cause appeared to be equally great at some foreign stations. Thus at Gibraltar 41 per cent. of the total deaths among the troops were caused by phthisis in the years 1837-46, while in the year 1875 only 23 per cent. of the deaths were due to this cause. At Malta we are told that in former years phthisis was the cause of 39 per cent. of the deaths, or nearly the same as at Gibraltar. Latterly there have been fewer deaths at Malta. In the island of Jamaica the deaths from phthisis in the years 1817-36 amounted to 7·5 per 1,000 of strength; while in 1859-66 the mortality from this cause had fallen to 1·42 per 1,000 of strength. In Trinidad, lung disease killed on an average 11·5 per 1,000 of strength between 1817 and 1836, while the mortality from this cause has now greatly diminished.

Turning from the warm stations of the Mediterranean, and the warm equable climates of the West Indies, to the extremely severe climate of Canada, we notice, in the first instance, that Canada is reckoned to be exceptionally healthy; and further, we are told that—

"The amount of phthisis has always been smaller than in some stations, and regiments of the Guards proceeding from London to Canada have had on two occasions a marked diminution of phthisical disease. The comparatively small amount of phthisis is remarkable, as the troops have at times been very much crowded in barracks. They have now the same allowance of space (600 cubic feet)."

In the twenty years 1817-36, the deaths from phthisis were 4·22 per 1,000 of strength, whereas in 1859-65, they were but 1·67 per 1,000. This improvement in Canada has been coincident with a similar improvement at home. The reporters call attention to the fact that these Canadian returns show how little the tendency to phthisis is increased by extremes or sudden changes of temperature.

Phthisis in India, per 1,000 of Strength.

	Died.	Invalided.
Bengal—		
1863-66	1·707	2·729
1867-70	1·752	3·636
Bombay—		
1863-66	1·526	3·280
1867-70	1·238	3·576
Madras—		
1863-66	1·458	3·656
1867-70	1·336	4·737

Army at Home.—1864-70.

	Died.	Invalided.
Household Cavalry	3·763	8·234
Cavalry of Line	1·416	4·025
Foot Guards	2·300	9·491
Infantry of Line	2·120	5·510

How regularly the cause of phthisis must be acting in India is seen, says Parkes ("Practical

Hygiene," p. 683), in the fact that in the four years, 1863-66, 74 men died from phthisis in the Bombay Presidency, and 73 in the Madras Presidency, the mean number of troops being in each case almost precisely the same (12,119 and 12,512.) For the next four years, with a smaller number of troops, 53 and 55 died in the two Presidencies.

The Table seems to me to show clearly that the immense range and variation of climates in which the troops serve in India have no effect whatever on the production of phthisis; and this inference is again strengthened by the fact that the mortality in Bengal from phthsis is almost precisely the same as in Canada.

A reference to the Table will show that there is less phthisis in India than at home. There can be no doubt that the causes of phthisis are less active in India; and if these causes are not climatic, must the difference not be found in the larger breathing space and greater lateral separations men have in India?

Among the causes of phthisis the most potent seems to be overcrowding in dwellings and the breathing of an impure air.

In Parkes' "Hygiene" mention is made (p. 123) of two Austrian prisons.

(*a*.) Prison in the Leopoldstadt, in Vienna, in which in the years 1843-47 there died 378 prisoners out of a total of 4,280, and of these 220, or 51·4 per 1,000, died of phthisis.

(*b*.) In the well-ventilated House of Correction, in the same city, in the years 1850-54, 43 prisoners died out of a total of 3,037, and of these 24, or 7·9 per 1,000, died of phthisis.

"The well-known fact of the great prevalence of phthisis in most of the European armies (French, Prussian, Russian, Belgian, English), can scarcely be accounted for in any other way than by supposing the vitiated atmosphere of the barrack-room to be chiefly at fault." This was the conclusion arrived at by the Sanitary Commissioners for the army. This view is strengthened by the fact that the British soldier has suffered from phthisis in the most beautiful climates, and every variety of station, *i.e.*, Gibraltar, Malta, West Indies, &c.

The deaths from phthisis in the Royal Navy averaged (3 years) 2·6 per 1,000 of strength, and the invaliding to 3·9 per 1,000. This is attributed to the foulness of the air on board ship. The degree of overcrowding met with on board ship is often excessive, and, if we are to accept the figures and statements published by Dr. Rattray in the Proceedings of the Medico-Chirurgical Society, in 1872, it is a matter for surprise that health on board ship is ever possible.

Dr. Rattray's observations (which are quoted by Parkes) were made on board H.M.S. *Bristol*, used for training cadets.

The cubic space for the crew to sleep in varied from 105 to 222 cubic feet, and that for the cadets from 242 to 506 cubic feet, and as the result of 150 analyses of the air, the carbonic acid was found to vary between 4·2 to 33·71 volumes per 1,000.

From what we have been saying, it will be gathered that much of the disease which is usually attributed to the effect of tropical climate may be avoided. If municipal, domestic, and personal hygiene demand our careful attention in temperate climates, this necessity is increased a hundredfold as we advance into the tropics. We have seen how health may be maintained in Arctic regions in spite of the necessary neglect of what in this country we have come to regard as the indispensable rules of health. When the dweller in northern climates, who has learned the art of living in spite of cold, turns towards the tropics, he is apt to forget that to live in warm latitudes requires scarcely any art at all, and he often finds to his cost that the dwellings, the clothing, and the diet with which he has comforted himself in the north are hindrances to health and comfort in the tropics. If the diet be moderated, if the clothing be adapted to the climate, if very ample cubic space be given in the houses, and, above all, if towns and dwellings be kept absolutely clean and sweet and free from every kind of decomposing filth, then we find that most of the diseases inherent to a tropical climate vanish.

Malaria.

There is one great class of diseases, however, which are practically unavoidable, and which demand our attention.

These are the various ailments which are attributed to malaria, and which include the various forms of intermittent and remittent fevers, and some forms of dysentery. Malarious diseases are due to peculiar conditions of the soil, and in order to understand the question, a few observations on "soil" in general become necessary. We have previously alluded to the effect of soil on temperature, and to the power it has of absorbing and radiating the sun's heat. Soils are of all degrees of porosity, between the solid rocks

on the one hand, and the loose sands and gravels on the other.

There is a general opinion that dry soils are more healthy than damp soils. Dryness or dampness of soil depend—(1) upon the amount of moisture brought to it; (2) upon the power of the soil to allow the wet to percolate; and (3) the configuration of the surface, and the visions for drainage.

All soils contain more or less organic matter, both animal and vegetable, as must be evident if we consider the constant additions to the surface, of dead leaves and vegetable *debris*, of animal excrement and animal remains. These may be washed into the soil by rains, or may be brought to it by rivers. Soils which, to the unaided eye, seem to be composed entirely of mineral matter, contain, in reality, considerable quantities of organic matter. This is the case in sandy plains, at the mouths of great rivers, as in Holland and the Landes, and it is also the case in some rocks which are much weathered and fissured, and which allow water to soak into them.

There is always active life in soil, or the potentiality of active life under favourable circumstances. Not only are there such animals as earthworms, but even in the driest soils there are found bacteria, which only require a certain amount of moisture and heat to start them growing.

The soil of towns, especially such a town as Munich, whose sandy soil is riddled with cesspools, is often sodden with sewage, and has its pores stuffed with excremental *debris*, and often no doubt contains the germs of specific diseases, such as typhoid, cholera, or phthisis. The pores of the soil are full of air, and this air always contains a large proportion of carbonic acid, a sure sign that fermentative, putrefactive, or respiratory processes are going on in it.

The gases in the soil may be drawn into neighbouring houses by the heat of the fires, and in fact coal-gas escaping from a pipe in the street has, in this way, been drawn into a a house, with fatal results.

In like way unwholesome gases, generated by the putrefaction of an impure soil, may find their way into houses, and with the gases doubtless the micro-organisms upon which the putrefaction depends, and possibly specific micro-organisms as well.

There are many micro-organisms which only flourish under certain conditions. Not only must there be organic matter for them to prey upon, and moisture and warmth to allow of their manifesting vitality, but the access of air is also necessary. If the soil be completely permeated by water, or if it be actually dry, then many forms of bacterial life languish, but when soil water which has been high subsides, leaving the soil moist and allowing full access of air, then bacterial life reaches a maximum, and we run great risk of zymotic disease. At least, so says Pettenkofer, who asserts that at Munich epidemics of typhoid and cholera occur with the recession of the subsoil water.

Of course, as the subsoil water gets low, the surface wells draw more and more upon the neighbouring cesspools, and the state of the soil need only act indirectly through the water supply.

The close connection between subsoil water and zymotic disease has not been observed to any great extent in this country. The fact that phthisis diminishes as the soil becomes drier and less sewage-sodden, a fact pointed out by Dr. George Buchanan, has a new interest now that tubercular disease has been found to be inseparably connected with a bacillus, and we seem to be brought within sight of a possible explanation of the connection between town drainage and a diminished death-rate from phthisis.

The best and in fact the only way to purify the soil is to cultivate it, and while we ought to be most careful that the soil round our houses (and beneath them) does not get overcharged with organic matter, we ought at the same time, by judicious planting, to take care that such organic matter as there is, is turned to its right use.

With regard to the production of malaria in a soil, all writers seem to be agreed that three things are necessary, viz., sufficient organic matter in the soil to undergo a fermentative or putrefactive change, and sufficient warmth and moisture to foster the process.

If the moisture be in excess (as when a marsh during winter is submerged), malaria ceases, and if the malarious soil be completely drained and dried, malaria ceases. It would seem to be necessary for the production of malaria that water should not be present in quantity too great to allow the access of air to the interstices of the soil.

Many marshy soils contain a very large amount of organic matter; and many other kinds of malarious soils, such as sandy deltas, contain more organic matter than at first sight appears likely; and many sandy malarious districts which appear dry have in reality a

layer of water not far below the surface. In spite of facts which appeared at one time adverse to such a conclusion, the opinion is now generally held that for the production of malaria we must have a soil containing organic matter apt for decay and putrefaction, and a certain amount of warmth and moisture. These are the conditions essential for that bacterial growth upon which putrefactive, fermentative, and similar disorganising processes depend. What is the nature of this malarial poison? In the first place, it may be carried by air or by water; secondly, it may be carried considerable distances, and may be wafted along a valley, up a ravine, or across a plain in the direction of the wind. This fact makes it unlikely that the poison can be a gas, for the law of diffusion and dispersion would soon render any gas practically harmless. Again, the behaviour of the poison, and the history and symptoms of malarious disease, make it unlikely that the poison is gaseous, for our knowledge of gaseous poisons almost forbids us to believe that any gas could give rise to exacerbations and remissions lasting for months, or even years. There are certain other facts, such as the power of a belt of trees to filter the poison out of the air, and the difficulty which it apparently has of rising far above the level of the ground in still weather, which make it likely that the poison is particulate. Krebs and Crudeli assert that they have discovered the malarial poison in the form of a bacillus, the *Bacillus malariæ*, which is found in the soil of the Roman Campagna. Although we can hardly believe that the poison can be anything but a microbe of some kind, the observations of these two savants, nevertheless, need confirmation.

Malaria is sometimes developed in other ways. The first turning up of a rich virgin soil is always a dangerous process in the tropics, and is very apt to be followed by an outbreak of malarious disease. It would seem as though the free admission of air to the interstices of the soil had the effect of starting that form of life on which malaria depends. Decaying vegetable matter, on a comparatively small scale, has occasionally given rise to malaria, and instances are recorded of the generation of malarious fevers from heaps of indigo-plants being allowed to rot and decompose, and from heaps of decaying vegetables. Malarious fevers have also broken out on board ship from similar causes. Given the conditions of soil which give rise to malaria, its virulence seems to increase with increase of temperature.

The only way of combating malaria seems to be the drainage and cultivation of the soil. The more productive the land can be made the less are the risks of malaria. In England malarious troubles have become rare, but if from any cause the land should go "out of cultivation," the political economist will have to take malaria into consideration in dealing with the results.

The cultivation of the land seems always to do good. The planting of the eucalyptus has been productive of good results in some places, and, at Sierra Leone, the growing of grass in the streets has been beneficial. In the course of centuries, possibly, many of the most deadly of the tropical foci of malaria may be subdued by the husbandman, but practically we have to regard malaria, at the present, as an unavoidable evil inherent to certain localities.

Occasionally malaria will develop in a place which has been previously healthy. This occurred in the Island of Mauritius, some sixteen years ago, and a glance at the Table showing the health of our troops in foreign stations at two different periods, will give some idea of the effect of this scourge on the British soldier.

The Mauritian fever seems to have been caused by the clearing of forests, the upturning of virgin soil, the increased defilement of the ground by increase of population, and the constant draining down of both animal and vegetable filth into a loose soil of slight depth. Then, in 1866, came deficient rainfall with a fall in the subsoil water, and the free admission of air to the interstices of the soil. The conditions being given, malaria broke out and still continues. Before 1866 there was no malarious disease in the island. Since then it has raged more or less continuously, and when the fever was at its height in 1867, quinine fetched as much as £40 per oz.

Mountain Climates.

A few words may be said as to the peculiarities of mountain climates, but this need not detain us long, since what has been previously said will have enabled us to anticipate what these peculiarities are. We will take, as an example, that district which is just now much visited by the British tourist and the British traveller, and which is doubtless well known to many here present—I mean Davos and the Engadin, in the canton of Grisons, Switzerland.

The health resorts in this district are between 5,000 and 6,000 feet above sea level. The barometer stands at about 25 inches instead of the average 30, which means that the atmosphere exerts a pressure of 12½ lbs. on each square inch of the body instead of 15 lbs., which is the normal at sea-level. As a consequence of this the blood-vessels of the skin dilate, and the inhabitants are singularly ruddy and healthy-looking. It is from the same cause, probably, that the capacity of the thorax increases, and the dwellers in this region are, as a rule, full-chested.

The weight of the oxygen in a given volume of air is less than in the plains, and to this, as well as to the diminution of pressure, is due the fact that the new-comer to this district feels short of breath, and the action of the heart and the respiration are both quickened at first. The body soon accommodates itself to altered circumstances, and in a few days the shortness of breath disappears, and pulse and respiration fall to their normal state. The temperature of the air is less than in the plains, the fall in temperature as we ascend being, on an average, about 1° Fahr. for each 300 feet.

The moisture in the air is slight, both absolutely and relatively, and the drying power of the air considerable. In consequence of the rarefaction of the air, and the slight amount of moisture, the sun's rays penetrate it easily, and have a remarkable power of heating solid bodies exposed to them. Thus the temperature in the sun may be scorching, while the shade temperature is freezing, or far below freezing. The power of the sun's rays is often increased in these regions by being reflected off rocks and snow, so that it often happens, in the depth of winter, that even invalids can saunter in the sunshine without discomfort or danger. The middle of the day is hot, but before and after sunset the cold is very great. The cold at night, however, is often not so great on the hill-side as it is in the valley; for the cold air, chilled by the icy mountain top, falls, by gravitation, to the lowest point, and settles in the valley.

The alterations of temperature are sudden, and the effect of the sun on the thin mobile atmosphere of these mountain districts is remarkable. There are few sights more astonishing or more beautiful than to see the sun rise in these districts, or to see him make his first appearance after a period of cloudy, rainy weather. The sombre valley, choked with woolly clouds, is cleared almost in an instant by the first ray of sunshine that falls into it. Solid masses of cloud are apparently licked up by the darting sunbeams, and peak and crag, glacier and tranquil lake, verdant alps, and picturesque chalets on the instant stand out clear and distinct, while the observer is as suddenly swathed in genial warmth, and is soon made to forget the cold and discomfort which characterise these regions when the sun forgets to shine.

The amount of rainfall and wind varies in accordance with aspect and local considerations. At great elevations there is a good chance of getting a pure air to breathe. If a town or village be perched on a mountain side, the filth and impurity will obey the laws of gravity, and flow away down the mountains to annoy those who live below, instead of breeding sickness at the spot where the filth is formed. It is, doubtless, the purity of the air which constitutes one of the most valuable elements of mountain climates.

The effects of these climates are seen in an increase of animal spirits, increase of appetite, increase of energy and power of muscular exertion. To enjoy a climate of this kind a fairly good constitution is necessary, and some power of taking physical exercise and withstanding cold.

A word of caution seems necessary, and it is this, that directly a health resort becomes the fashion it is within measurable distance of ruin. Density of population brings with it its attendant evils, difficulties of water supply and drainage, accumulations of filth, and an atmosphere stuffed with microbes. The authorities at these places cannot be too careful to prevent the close packing of houses and the erection of barrack-like hotels without adequate curtilage.

For healthy tourists, who are constantly on the move, and who are out of doors all day, and who are strong enough to tolerate fresh air even in their bedrooms, the question of hotels is, after all, a minor matter. But to send a consumptive patient to spend twenty or twenty-two hours out of every twenty-four hours during the winter in a barrack filled with consumptives like himself, is a proceeding which is more likely to do harm than good. The one thing a consumptive patient needs more than anything else is fresh air to breathe. An overcrowded hotel which smells of drains, dinners, and humanity, is not an ideal spot in which the consumptive should seek health.

The facts which I have brought before you must lead to the conclusion that a large proportion of the disease which is loosely attri-

buted to "climate" is, in reality, due to a wanton neglect of sanitary rules.

Sanitary rules with regard to ventilation, cubic space, and the disposal of filth, rules which we find it so necessary to observe even in a temperature like ours, demand far more scrupulous observance in the tropics. The majority of diseases which are fatal to us in the tropics are in fact filth diseases, and, with the exception of malaria, there can be no doubt that much of the sickness and mortality of tropical countries is distinctly avoidable.

In order to give point to this assertion, I cannot do better than call attention to the West Coast of Africa, a district with a most evil reputation as regards health.

It will be profitable to glance at the causes of mortality in this dreaded region, and ascertain to what extent that mortality is inevitable. Sierra Leone has at present a population of about 37,000, and a garrison of some 500 black troops. There are mangrove swamps north and south of the town. The water supply is good. From 1817 to 1837 the mortality among the whole white population was about 17 per cent., and among the troops the army returns show that there were annually 2,978 admissions to hospital, and 483 deaths per 1,000 of strength. It thus appears that the military death-rate at that period was not far from being three times as great as the civil death-rate.

If we turn to the causes of this terrible sickness and mortality among the troops, we find that malaria was a great cause of sickness, but not a great cause of death, and that yellow fever and dysenteric disease were among the most fatal complaints. Yellow fever is an acute infective disease, which occurs especially in climates where the temperature ranges above 70° F., although it may drag on a languishing existence even in temperate climates like this. Recent researches show that yellow fever is not in any way connected with malaria, but that it is a tropical filth disease, and that the great causes of its localisation are (according to Parkes) overcrowding and the accumulation of excremental matters round buildings:—

"And here we find the explanation of its localisation in the West Indian Barracks in the olden times. Round every barracks there were cesspits, often open to sun and air. Grant that yellow fever was somehow or other introduced, and let us assume (which is highly probable) that the vomited and fæcal matters spread the disease, and it is evident why, in St. James's Barracks, at Trinidad, and St. Ann's Barracks, at Barbadoes, men were dying by dozens, while at a little distance there was no disease."

Again, with regard to dysentery, we find the opinion very strongly expressed that its chief causes are impure water and impure air, brought about by overcrowding and fæcal emanation. To these causes must be added injudicious feeding and drinking. The errors of diet which seem to predispose to dysentery are, mainly, the taking of food in an early stage of decomposition, and a diet of imperfect construction, and such as leads to a scorbutic habit. The dysentery which was so fatal to the troops on the West Coast of Africa, was, we are told, chiefly scorbutic.

"The causes of this great mortality were simple enough. The station was looked upon as a place of punishment, and disorderly men, men sentenced for crimes, or whom it was wished to get rid of, were drafted to Sierra Leone. They were very much overcrowded in barracks, which were placed in the lower part of the town. They were fed largely on salt meat, and being, for the most part, men of desperate character, and without hope, they were highly intemperate, and led in all ways lives of utmost disorder. They considered themselves, in fact, under sentence of death, and did their best to rapidly carry out the sentence."

So frightful was the mortality on this dreaded West Coast, that the white troops were ultimately replaced by black troops from the West Indies, and it is estimated that the total white population of Sierra Leone, of late years, has not exceeded 200.

From what has been said, it is evident that much of the sickness on this coast is preventable, and, indeed, of late years the health of Europeans at this station has been much improved.

The housing and feeding of the troops has undergone marked improvement, and the growing of Bahama grass in the streets and round the houses is supposed to have ameliorated some of the climatic conditions.

In the four years, 1863-66, we are told that eight non-commissioned officers (white) died on the West Coast, and of these eight, three died of liver disease, two from *delirium tremens*, two from fevers, and one from dysentery. It would be difficult to say which of these eight died from unavoidable climatic conditions.

Among the black troops serving at Sierra Leone and the adjacent stations, phthisis and

lung diseases appear to be the most fatal disorders.

In the ten years, 1861-70, the deaths were 22·49 per 1,000 of strength, and of these phthisis caused 7·05 per 1,000 of strength. In some years the deaths from phthisis were in greater proportion.

In 1862, phthisis, killed 12·6 per 1,000, and pneumonia 9·46 per 1,000. In 1863, phthisis killed 9·3 per 1,000, and in 1867 tubercular disease killed per 1,000 of strength—17·71 in Sierra Leone; 15·87 at the Gambia; 12·58 at the Gold Coast and Lagos. In 1862, we are told, there were only 5 cases of intermittent and 18 of remittent fever (23 cases of malarious disease) among 317 negroes.

At Gambia, as at Sierra Leone, phthisis and lung diseases were the chief causes of death among the black troops, and the reason for this is to be found, probably, in the ill-construction and bad ventilation of the barracks. Speaking of the West Coast generally, Dr. Parkes says :—

"There is no doubt that attention to hygienic rules will do much to lessen the sickness and mortality of this dreaded climate. In fact, here, as elsewhere, men have been contented to lay their own misdeeds to the climate. Malaria has, of course, to be met by the constant use of quinine."

The other rules are summed up in the following quotation from Dr. Robert Clarke, who is a most competent judge of the climate of this coast :—

"Good health may generally be enjoyed by judicious attention to a few simple rules. In the foremost rank should be put temperance, with regular and industrious habits. European residents are too often satisfied with wearing apparel suited to the climate, while they overlook the fact that exercise in the open air is as necessary for health here as elsewhere. Many of them likewise entertain an impression that the sun's rays are hurtful, whereas, in nine cases out of ten, the mischief is done, not by the sun's rays, but by personal habits.

"Feeling sadly the wearisome sameness of life on this part of the coast, recourse is too frequently had to stimulants, instead of resorting to inexhausting employments, the only safe and effective remedy against an evil fought with such lamentable consequences. Europeans also bestow too little attention on ventilation, far more harm being done by close and impure air during the evening and night than is ever brought about by exposure to the night air. Much of the suffering is occasioned by overfeeding."

Nothing can show more conclusively the value of the labours of the sanitarians both at home and abroad than the subjoined Table showing the sickness and mortality of British troops per 1,000 of strength, on home and foreign stations, and for two periods in 1861 and the decade, 1871-80.

It will be observed that the mortality has been lessened at all stations save two—the Cape and Mauritius. The increased mortality of the Cape is accounted for by the Zulu campaigns, and that of the Mauritius by the appearance of malaria in the island :—

HEALTH OF BRITISH TROOPS AT HOME AND ABROAD.

Per 1,000 of strength.

	1861.*		1871 to 1880.†	
	Annual admissions to hospital.	Mortality.	Annual admissions to hospital.	Mortality.
India	1,768	37	1,454·3	19·37
China	1,492	28	1,196·3	13·8
Ceylon	1,440	20	971·3	15·26
Bermuda	461	14	632·7	8·72
West Indies	1,002	13·5	913·6	11·02
Cape & St. Helena	950	11·0	899·2	39·96‡
Mauritius	608	12	1,834·7	17·13
Malta	772	11	857·1	9·77
Canada	644	8·2	667·9	6·64
Gibraltar	927	9·0	675·9	6·67
United Kingdom	1,025	9	817·5	7·95
On board ship	...	...	571·5	7·64

The facts which we have been considering in these three lectures and the reflections which we have made will, I hope, prevent us from being hasty in condemning the climate of any country or locality as "unhealthy." Healthiness and unhealthiness are to a great extent in our own keeping all the world over. "The pestilence which stalketh in darkness" does so mainly because our eyes are shut, and we have long been in the habit of blaspheming the unseen powers for "sending" us diseases which are clearly of home manufacture. Ignorance and filthiness have in times past turned many an earthly paradise into a plague spot. Let us hope that the dawn of better things is at hand, and that when those who

* Army Medical Report, quoted by Dr. Aitken ("Science and Practice of Medicine," second edition).

† Army Medical Report, 1881.

‡ Campaign.

plume themselves on being the enlightened sons of civilisation take possession of some island of the tropics, the lines of Bishop Heber may be in no ways applicable, in which he tells us that—

"Every prospect pleases,
And only man is vile."

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The number of visitors to the Exhibition for the week ending Tuesday, 21st inst., was 139,591. Total since the opening, 1,616,523.

ELECTRIC LIGHTING IN ITALY.

Great progress is being made at the present time in electric lighting, and town after town is rapidly availing itself of this means of illumination. The Edison Company are firmly established at Milan, and have for some time past lighted the Victor Emmanuel Gallery and numerous shops, as well as the La Scala theatre, from their central station at St. Radagonda, and are now extending their operations and have recently completed an important installation for lighting the Piazza del Duomo.

At Genoa, the railway station has recently been lighted by electricity, and within the last few days an experiment for the illumination of the Piazza Acquaverde has been made. Several of the large passenger steamers running between this port and South America are lighted by electricity.

The railway station at Turin, Piazza Carlo Felice, and the Regio theatre have been lighted for the last two years by electricity, Messrs. Siemens' arc lamps being used for that purpose, and last year, during the Exhibition, the garden of the Valentino were effectually illuminated by electricity, and opportunity was thus afforded to the public of judging of the relative value of the various systems of lighting. The principal entrance to the Exhibition and a portion of the gardens was lighted by 48 arc lamps of the Siemens type, whilst the remainder of the illumination consisted of 100 arc lamps furnished by Herr Ganz of Buda-Pest, Egger and Kremenzky of Vienna, and Spiecker of Cologne, making in all 148 arc lamps distributed on the circuits; a total length of twenty-two miles of conducting wires being used for their installation. The Royal Pavilion, galleries, &c., were lighted with upwards of 1,000 incandescent lamps of the Edison, Cruto, Bernstein, Swan, and Victoria systems.

The Town Council of Turin have at last decided to light the principal streets and squares by electricity, and have taken into consideration two proposals for the purpose. The first was submitted by the National Company for the Distribution of Electricity by Secondary Generators (Limited), to whom a prize of 10,000 lire, given by the Minister of Agriculture and Municipality of Turin, was awarded at the Exhibition for the most important application of electricity to industrial purposes. The other proposal for lighting the other half of the town has been made by one of the gas companies. The first mentioned company will light the Piazza Castello, Via Garibaldi, and Piazza dello Statuto, as well as the Piazza del Palazzo di Città; whilst the latter intend lighting the Piazza Vittorio Emanuele, Via Po, Via Roma, and Piazza St. Carlo. The Piazza Vittorio Emanuele will be lighted by twelve arc lamps of 1,000 candle-power each, and by 20 incandescent lamps of 50 candle-power each under the arcades. The Via Po is to be lighted externally by ten arc lamps of 800 candle-power, and by 50 incandescent ones of 50 candle-power under the arcades. The four angles of the Palazza Madama in the Piazza Castello by a similar number of arc lights of 5,000 candle-power each, whilst the arcades will be illuminated by 30 incandescent lamps of 50 candle-power. Two arc lamps of 800 candle-power will serve to light the Galleria Subalpina, whilst 40 incandescent lamps of 50 candle-power will illuminate the Via Roma on both sides of the Piazza San Carlo, which will be lighted by six arc lamps of 800 candle-power outside and by ten incandescent lamps 50 candle-power each under the arcades. The Via Garibaldi (about one kilometre long) will be lighted with twelve arc lamps of 800 candle-power, and the Piazza dello Statuto by eight arc lamps of 800 candle-power, and by 30 incandescent ones under the arcades. Finally, the Piazza di Palazza di Città by two arc lamps of 800 candle-power, and five incandescent ones under the arcades.

The total candle-power of the proposed illumination will be 73,250, or about eight times the quantity of light given by the gas lamps at the present time. The annual price to be paid for this illumination is 130,000 lire, or 50,000 lire in excess of that now paid to the gas companies; and according to the terms of the contracts the whole installation is to be in complete working order by the 1st January, 1886.

It will be recollected that one of the principal attractions in the electrical department of the Turin Exhibition was the transmission of electrical energy to great distances, in connection with the secondary generators exhibited by M. Gaulard on behalf of the National Company, which has now undertaken to light Turin, and an account of the experiments that were made with this system during the Exhibition will not be out of place here. This system consists in the employment of a main circuit of high tension electricity generated at a central station, which current, by means of the secondary generator of M. Gaulard, is, at the points where the electricity is re-

quired to be utilised, converted into currents of the required potential.

The current in the main circuit is an alternating one of high electromotive force, and at the subsidary stations forms the primary circuit of the secondary generators. In correspondence with the primary circuit of the generators, secondary circuits are arranged, in which at each reversal of the primary current a secondary one is induced, this induced current being the one that is directly utilised. The secondary generator, as it is called, consists of a pile built up of a number of spiral pieces of sheet copper insulated by rings of suitable non-conducting material placed between each turn; as these sheet lengths, or divisions of the generator, can be coupled in series, and in a variety of ways, it is evident that when the grouping of the secondary coil is made in a similar manner to that of the primary one, the current induced by the latter in the former will be of equal potential to it; but when the arrangement of the grouping differs in the primary and secondary circuits, then a current of a different potential will be induced in the secondary one, and in this manner it will be possible to transform a high tension primary current into one of low tension, suitable for the particular purpose to which it is to be applied, whatever it be, for high or low volt power lamps, for electro-metallurgy, or for the production of mechanial power. An important experiment was made in the presence of the International Jury for the electrical department at the Turin Exhibition last year, consisting in lighting the railway station of Lanzo by a current produced in the Exhibition building. The primary current was furnished by a Siemens alternate current machine of the electromotive force of 2,000 volts, requiring about 60 horse-power. This dynamo was driven by the fine engine of 220 indicated horse-power exhibited by Messrs. Tosi and Co., of Legnano, one of the largest in the Exhibition. This current, which was of high tension and small quantity, is transmitted by a copper wire 3½ millimetres (less than ⅛-inch) diameter fixed to the telegraph poles, to the railway station of Lanzo, a distance from the Exhibition of 40 kilometres, thus making a circuit of 80 kilometres (nearly 50 miles).

The secondary generators by which the primary current was transformed into electricity of the potential required for the various descriptions of lamps used, were established in five places, viz., one in the Exhibition building, where it supplied 9 Swan, 9 Bernstein, and 1 Soleil lamp; a second at the Chalet of "Le Figaro" (newspaper), in the grounds, which was lighted by 5 Bernstein lamps; a third generator at the Turin terminus of the Lange railway, lighted by 2 Siemens arc lamps; a fourth at the Venesia railway station, supplying 2 Siemens lamps; whilst a fifth, at the Lanzo station, which was lighted with 10 Swan, 9 Bernstein, 2 Siemens, and a Soleil lamp, distributed in the offices, café, and outside the station. The experiments were highly satisfactory, the lamps giving as clear and steady a light as if they were in the grounds, instead of being some twenty-five miles distant.

A company has recently been formed in Turin, with workshops at Piossasco, for manufacturing the Cruto incandescent lamp, which gave such satisfactory results at the Turin Exhibition, and, from its efficiency, agreeable effect of light, and durability, is establishing a permanent footing in Italy. This lamp was first brought before the public in 1882, at the Exhibition of Elecricity at Munich. It is well known that various substances have been used for producing the filament of carbon employed in all systems of incandescent lamps. Edison now uses a thin flat strip of carbonised bamboo; Swan, a cotton thread parchmentised in sulphuric acid, and afterwards carbonised; others, cardboard, silk thread, &c. Signor Cruto, on the other hand, has succeeded in producing a capillary tube of carbon by the decomposition of a gas rich in hydrocarbons, the carbon being deposited in a thin crust on a piece of fine platinum wire, which platinum is afterwards volatilised by passing a strong electric current through it, leaving in this manner a fine tube of carbon remarkably elastic and metal like.

In order to obtain a wire sufficiently fine, the platinum is first coated with silver; the compound wire is then drawn out as fine as it is possible, and the silver afterwards dissolved away with nitric acid, as in the process first introduced by Dr. Woollaston. In this manner, with an equal cross-sectional area of carbon filament, and consequently with an equal resistance to the electric current, Signor Cruto claims to have obtained a greater circumference, and consequently larger illuminating surface, than is the case with the filaments of other makers which are not tubular. Another advantage claimed for this lamp is, the quantity of electricity required for one of 16 candle-power is 25 per cent. less than by other system, one horse-power being sufficient to supply twelve Cruto lamps of 16 candle-power each. These lamps are made of various luminous intensities, the stock sizes being from 4 to 100 candle-power.

BALATA INDUSTRY.

In the *Journal of the Society of Arts* for Nov. 20th, 1863, a list of subjects for premiums was published, amongst which was one "For any new substance or compound which may be employed as a substitute for India-rubber or gutta-percha in the arts and manufactures."* This was responded to in the *Journal* for February 26th, and March 4th, 1864, a letter being published in the latter from Sir William Holmes, from British Guiana, advising the despatch to the Society of a box containing samples

* In a paper on "Gutta-percha in Surinam," Professor Bleekrode described balata as the product of a tree named by him *Sapota Mulleri*. *Journal*, vol. v. p. 625, Oct. 9, 1857. See also vol. viii., p. 713, and vol. xxxii., p. 14.

of balata, both in the fluid or milky, as well as in the dried or coagulated state. In the letter referred to, Sir William Holmes speaks of the small specimen which was exhibited in the International Exhibition of 1862 as attracting a considerable amount of attention, and further says, so far as he could judge, balata was not to be rivalled either by India-rubber or gutta-percha, possessing "much of the elasticity of the one, and the ductility of the other, without the intractibility of India-rubber, or the brittleness or friability of gutta-percha." Sir William Holmes further expressed a hope that balata would, ere long, be included as an important item amongst the exports of the colony. Notwithstanding that this was written so far back as 1864, little or nothing has been done since towards making balata a regular article of import; occasional notice has been drawn to it from time to time, and the subject as frequently allowed to drop. As a proof of the truth of Sir William Holmes's statement as to the ductility of balata, it may be mentioned that a sample of that exhibited in the Exhibition of 1862, and presented to the Kew Museum at the close of the Exhibition, is still in a fairly ductile state, and shows no such brittleness as is the case with gutta-percha.

In connection with this subject of the development of balata, Mr. G. S. Jenman, Government Botanist, and Superintendent of the Botanical Gardens in British Guiana, has just drawn up a very exhaustive report, the result of which, it is hoped, will be to bring the substance into a regular commercial channel.

The title of the report is "Balata and the Balata Industry, Forest Laws, &c.," and it commences with a very interesting description of the bullet tree region, including its inhabitants, character of the vegetation, &c. Coming to the immediate subject of the report, Mr. Jenman describes the bullet tree, from the bark of which balata is obtained, as a large forest tree ranging from Jamaica and Trinidad to Venezuela and Guiana. He refers it to *Mimusops balata*, and says—"The vernacular name appears to be applied to two species or sub-species which are united by Grisebach, in his 'Flora of the British West Indies.' Young plants of *Mimusops globosa*, of Jamaica and Trinidad, growing in the Gardens, seem to be distinct from the Guiana type. The tree grows to a height of 120 feet, and has a large spreading head. The trunk is nearly cylindrical. The bark is about half an inch thick, with deep parallel fissures an inch or so apart. The hard reddish-coloured wood is one of the densest in the colony, and is used for all sorts of purposes where great strength and durability is required. The tree is more plentiful in both the eastern and western parts of this colony than in the intermediate region. From the east bank of the Berbice river to the Corentyn is the region of its greatest plentifulness in the colony, but its distribution extends still eastward beyond the Corentyn into Dutch Guiana, where a grant of several hundred thousand acres has recently been acquired by an American firm for collecting balata. The trees are more plentiful in this region in the depths of the forest than near the rivers, hence the creeks form arteries to the balata grounds. Several of the creeks on both sides of the Canje are instances of this. The wood cutters of this district regard the tree as inexhaustible; in the interior of the forest it exists in profusion and abundance, and lies beyond the reach of the balata collectors as they at present conduct their operations. As the trees near at hand become exhausted, they will no doubt alter their habits, and make clearings as drying places in the heart of the forest; but now they are under the obligation of returning to the settlements on the creeks with the milk they have collected to dry. Under this necessity they can at most only penetrate about two days' journey, but, so far as they have explored, they report there is no diminution in the abundance of the trees. The forest at this depth, of course, has never been touched by woodcutters, as, for convenience in getting their timber out, they have to confine their operations to the banks of the river and creeks, rarely going in more than a mile or two."

Regarding the character and value of balata, Mr. Jenman says its strength is very great, and as it does not stretch under tension, for special appliances, such as bands for machinery, it is unequalled. It has recently been pronounced by an American firm of manufacturers as "the best gum in the world."

Dr. Hugo Müller, F.R.S., in a report on the substance says: "It seems that balata is by no means neglected, and in fact it would find ready purchasers if more of it came to the market; as it is, the supply is very limited, and generally it comes only once a year. It commands a higher price than gutta-percha, and this in itself is a proof of its usefulness. It is used almost in all cases in which gutta-percha is used, but on account of its higher price, only for superior purposes. It seems that balata is treated by the manufacturers simply as a superior kind of gutta-percha, and, therefore, its name disappears when manufactured. Nevertheless, balata is distinctly different from gutta-percha, and this is especially manifested in some of its physical characters; for instance, it is somewhat softer at ordinary temperatures, and not so rigid in the cold.

"In one respect balata shows a very marked and important difference from gutta-percha, and that is its behaviour under the influence of the atmosphere, whilst gutta-percha, when exposed to light and air, soon becomes altered on the surface, and changed into a brittle resinous substance, into which the whole of the mass is gradually converted in the course of time. Balata, on the other hand, is but slowly acted upon under these circumstances. The electrical insulating quality of balata is said to be quite equal to that of gutta-percha."

Mr. Jenman says that the collecting of balata is an open and recognised business, is carried on only in

Berbice, but he proceeds to show that the greater part of that so collected is not obtained from trees on Government grants, but surreptitiously from Crown lands; and Mr. Jenman further says that much damage is done to the Crown lands by the depredations of collectors, and "that it is desirable, in the interest of the colony, till effective rules are devised for the protection of the forest and the preservation of this valuable wood, that the trade should be discontinued."

The life of the balata collectors is a very hard one. The ground they have to traverse is generally very wet and swampy. In many cases the traveller sinks at every step up to his knees, and this continues for miles, and water often has to be waded through up to the armpits. When the collecting ground is not too far distant, women sometimes accompany the men, and cook or assist in laying out the calabashes, and collecting the milk while the men fell and ring the trees. The collectors connected with a grant sell the milk they collect to the agent on the grant, and never dry it themselves. The price for pure milk is four shillings per gallon, or occasionally a dollar, and for clean well dried balata one shilling per pound. Considering the circumstances of the people who follow it, balata collecting, if pursued with industry, is a paying business. The calling pays better, while the season lasts, than the best mechanical trade; with fair weather, a man can earn from one to five dollars a day at it, and an exceptionally expert collector has been known to make twenty dollars in three days.

The instruments used in collecting the milk are an axe for felling the trees, a cutlass for making the channels in the bark to cause the milk to flow, and two or three gourds in which to collect the milk. The collector commences operations by chipping a piece of the bark from the selected tree, and if the milk runs well he quickly shaves the moss and rough bark from the side he intends to tap, then stooping down with his back to the front of the tree, but on one side of it, he cuts from the base of the tree obliquely upwards towards himself, in the bark, a narrow channel, then moving round the other side, a similar one. These grooves are generally about eighteen inches long; they form an acute angle at the base, just below which a niche is cut in the bark and is slightly lifted with the end of the cutlass, and a calabash inserted by the rim under it. Occasionally a piece of palm or maranta leaf is inserted under the bark, and the calabash is placed on the ground, the leaf conducting the milk into it. The channels are then quickly cut upwards parallel to each other on the opposite sides, about ten inches apart, the operator continuing them as far as he can reach, which is about eight feet from the ground. The milk trickles from cut to cut down this zig-zag line into the calabash beneath. The best collectors cut the bark with much neatness and precision, and do not injure the trees; but little care is usually taken, and the wood is injured with every stroke of the cutlass, the result being that numerous trees are killed, and left standing. Large trees are always tapped on the opposite sides, careful collectors leaving the intervening spaces for subsequent years. It takes from five to ten minutes to cut the channels in each tree, and the milk runs from forty to sixty minutes; at first it forms a little rivulet, but after about twenty or thirty minutes, it only drips. After a little use, the gourds become so coated on the inside with dry balata, that they have to be occasionally soaked in water, when it peels off freely, leaving them perfectly clean again. The yield of a tree varies according to circumstances. If favourable, a tree 15 inches to 20 inches in diameter, bled 8 feet high, will yield 3 pints of milk. Trees are often felled, and then tapped by ringing the bark in parallel transverse lines, at intervals about a foot apart.

To dry the milk, it is poured into shallow wooden trays, the insides of which are previously rubbed over with oil, soap, or grease, to prevent the balata sticking, and the substance is exposed to as much air as possible, and sometimes to the sun. In fine weather it takes two or three days to dry, and in wet weather a week or more; when it is sufficiently dry to be removed from the boxes, the sheet is thrown over a line, or bar, to drip, and become hard.

A good deal of foreign matter is found in the milk, and Mr. Jenman says adulteration is systematically carried on, and the agents have at all times to be on their guard against it.

The report concludes with a consideration of the damage done to the forests, and some remarks on their better conservation.

Correspondence.

THE LONDON SCHOOL BOARD DRILL COMPETITION FOR THE SOCIETY'S BANNER.

It may be satisfactory to our members to state, as I was assured by the Chairman of the London School Board on Saturday, 11th inst., that the banner given by the Society attains its object with increasing satisfaction. It may be held forth for imitation elsewhere, for emulation in physical exercises, as well as for excellence in military drill. Sir Robert Rawlinson, who attended with me, and who has been a soldier, greatly admired the excellence in military evolutions which the boys displayed. They were as good as those of the Guards, or of the police. I was well satisfied with the evidence of sanitary progress displayed at this last review. At the former early exercises, the boys presented only a sorry appearance; their countenances were pallid, and generally of a tallowy aspect, and their dress, in the larger proportion, poverty-stricken. On Saturday, the prevalent aspect was of a decidedly improved fresh tint, that I believe would have satis-

fied Dr. Richardson of their greatly improved health; their dress and array was highly improved, and, with their caps of one colour for each district, produced an agreeable impression. I was glad to learn that exercises on the Swedish system were in course of introduction for the girls, and Kinder-garten exercises for children. I beg to be permitted to express a hope that the members of the School Board will not shrink from the expense of providing qualified teachers, and of getting appliances for the improvement of physical as well as mental training.

EDWIN CHADWICK.

AGRICULTURE IN CHILI AND IN TURKEY.

In the last number of the *Journal* is an interesting and accurate account of agriculture in Chili. This exactly fits Turkey, in Asia and many other countries.

This may appear strange, but the explanation is simple. A common base is Spain, and many of the institutions of that country being received from the east, are types of that region, sometimes as far as China. On the other side, they have been propagated by Spain in Central and South America.

The moral, if moral anyone wants, is this—that there are few matters of information we acquire which are not of much wider application, if we know how to apply them, and that it is worth while to learn anything thoroughly.

HYDE CLARKE.

32, St. George's-square, S.W.

General Notes.

PORT OF JEDDAH.—According to a report of the Austro-Hungarian Consul, it appears that this port, which was once the most important on the Red Sea, has lost considerably since the opening of the Suez Canal. The trade is principally in the hands of native merchants, and is carried on chiefly by barter, cash transactions being exceptional. The natives seldom pay when due, but, generally speaking, in monthly instalments; failures, however, are exceedingly rare. The trade is chiefly an import one, but it is limited on account of the barrenness of the country and the dearth of industries.

THE ST. ETIENNE RIBBON INDUSTRY.—The *Moniteur des Fils et Tissus* reports that the production of the above industry for 1884 amounted to a value of £2,441,600 as against £2,742.000 in 1883. The reduction in the above case might have been greater if the figures of the local condition house be taken into consideration. In 1883 there were 672 tons of silk conditioned, while in 1884, the quantity was only 471 tons. During the year 1870 to 1876 the annual production was £3,600,000 to £3,840,000, of which two-thirds was exported. The present exports are only about £725,000, so that the loss can be attributed to diminution of exports, while domestic trade has made some progress. It is, however, remarked that on account of the lower prices now current for raw material and labour, as compared with 1870-76, the reduction in quantity is really only about 20 per cent. Manufacturers are in hopes that the more favourable indications presented by some branches of the trade during the earlier part of 1885, will lead up to a general revival of their industry.

TUBE WELLS AT ROME.—A trial was made, a few days since, in the presence of the Secretary-General and other officials belonging to the Ministry of Agriculture, in sinking Norton's tube wells. The experiment was highly successful, and good potable water was obtained at a depth of 6 metres (20 feet) below the surface. It is considered that these wells will prove of great utility in the Roman Campagna, and the minister has ordered further experiments to be made, to which the various agricultural societies will be invited.

PISCICULTURE IN ITALY. — The Minister of Agriculture, with a view to encouraging pisciculture in Italy, has sent two students abroad in order that they may learn the various systems of fish culture as is carried on in other countries. Prizes also are offered to such municipalities or other bodies that may have, by their efforts, improved the condition (as regards fish) of fish rivers, lakes, or streams under their control. 450,000 trout ova have been purchased from the piscicultural establishment of Tabole, on the Lake of Garda; 100,000 trout ova from the Imperial establishment of Uniga (Alsatia); 100,000 salmon trout, and 100,000 ova of other fish, including eels, at Schuster, near Friburg (Baden). These ova will be used for stocking the rivers Po, Adigi, Ticino, Upper Arno, the lakes of Como, Orta, Isea, Idro, Santa Croce, and Trasimena.

PRODUCTION OF OPIUM IN MACEDONIA.—The production of opium in Macedonia is one of the principal resources of that country. In 1883, from 65 to 70,000 kilogrammes were sent from the interior to the port of Salonica, and in the following year it had increased to 88,000 kilogrammes. The prices in 1883 ranged from 32 frs. to 39 frs. per kilogramme, whilst last year they varied from 32 frs. to 43 frs. At the present time, in consequence of the small demand, they are as low as 27 frs. per kilogramme. From 35 to 48 kilogrammes of poppy seed are required to produce one kilogramme of opium. The seed is worth from 28 frs. to 31 frs. per quintal (100 kilogrammes). The cultivation of the poppy has greatly increased lately, and the production of opium a few years ago was from 15,000 to 20,000 kilogrammes annually. About 70 per cent. of the total production is exported, principally to London and Antwerp. The value of opium produced in 1883 amounted to 2,700,000 frs., whilst that of 1884, of which 3,000 kilogrammes still remain in the warehouses, it is estimated will amount to 3,500,000 frs.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

SOCIETY OF ARTS EXAMINATIONS.

The Programme for 1886 is now in the press, and will be issued shortly. The Examinations will be held on the 12th, 13th, and 14th of April. The only alteration in the scheme is the removal of "Sanitary Science" from the list of subjects, an examination in Hygiene having been recently instituted by the Department of Science and Art. The Practical Examination in Vocal and Instrumental Music will be held at the Society's House in May.

Proceedings of the Society.

CANTOR LECTURES.

PHOTOGRAPHY AND THE SPECTROSCOPE.

By Capt. Abney.

Lecture I.—Delivered April 20, 1885.

Every lecturer, when he begins, must have a text of some description, and I propose to make my text for the lectures a plate exposed to the spectrum. You see before you a spectroscope comprising a collimator, two prisms, and a camera, with a lens of 13-inch focal length, and in this slide is a sensitive collodion plate.

The spectrum of the hot carbons of the electric light is upon the focussing screen which you see before you, and I will simply expose this plate, and refer to it from time to time as my lecture continues

The plate is given six seconds' exposure to the light of that spectrum, and now in the subdued light coming from this lantern, whose sides are covered with translucent orange paper, I see the picture is coming out under the action of the ferrous oxalate developer. After fixing, we see that we have the photographed spectrum on the plate.

This is the text on which I have to hang my lectures. We have three things to consider. First of all, we have got the light, then we have the apparatus, and then the sensitive material on which the spectrum is taken. The white light from the carbon poles, in passing through the apparatus, is spread out into a coloured band, which we call the spectrum; and the spectrum has effected a change in the sensitive salt of silver, as is shown by the blackening on the application of what is called a developer. The cause of the change in the sensitive material is what I first address myself to.

To conceive a right notion of photographic action we must first of all conceive, in the most elementary manner, the structure of matter. The structure is beyond our actual visual acquaintance, but we may be able to visualise it from the way it behaves; we have to draw our conclusion about it from evidence of an experimental nature. What we want to get is a mental picture of matter.

Physicists have come to the conclusion that homogeneous matter is composed of molecules, or small masses which are altogether similar one to another, *i.e.*, they have the same composition. In different matter these molecules have different weights. Further, it is believed that the molecules, or the small particles of matter, are themselves composed of atoms, which we take to be the fundamental unit of matter. Now, from experimental data, Sir William Thomson and others have come to conclusions as to the limits of the size of these molecules, and also as to their distribution in space. From the kinetic theory of gases, it is concluded that the diameter of a molecule lies somewhere between one twenty-five millionth part of an inch and one two hundred and fifty millionth part of an inch. Further, in gases it is conceived that the molecules are free to move in straight lines in any direction, the direction being altered only when the molecules collide; that is to say, when they strike one against another. In a liquid, the particles are bonded much more closely together, and the free path of the molecules is very much shorter. That is to say, that they cannot go

from one place to another without very much more frequently coming into contact with other molecules; and the molecules pass from place to place at a very much slower rate than they do in gases. A solid, such as is our silver salt, is conceived to be such that the molecule has no free path, but is confined in a limited space in which it can oscillate, moving round a mean centre. As to the distribution of these molecules in liquids and solids, Sir William Thomson has arrived at very definite conclusions also. In a lecture at the Royal Institution, he said that he concludes that in every ordinary liquid, or transparent solid, or seemingly opaque solid, the mean distances between contiguous particles is less than one twelve millionth of an inch, and more than one two thousand five hundred millionth part of an inch. Those are big figures, but still the distance apart is very small. "To form a conception of this," he says, "imagine a globe of water as large as an ordinary football to be magnified to the size of the earth, each constituent molecule being similarly magnified. The magnified structure would be more coarse grained than a heap of small shot, but probably less coarse grained than a heap of footballs." So you see that, by magnifying to this extent, you have a coarse-grainedness which, of course, is only relatively coarse grained after such an enormous magnification. Or you may put it in a different sense. If you magnify eight thousand diameters by an ordinary microscope—and that is about the limit to which a microscope will magnify; and if you magnify that eight thousand diameters again eight thousand times, you would be able to see the molecular structure of water. So much, then, for molecules.

We will now turn to the atoms. These will not bear such a very large disproportion of size to the molecules as do the molecules to the smallest visible particles. We must, however, I think, conceive that every atom (and this is an important point) is charged with energy very much in the same way that the magnet is charged; only, instead of two poles, as a magnet has, each atom has only one pole. It is unipolar.

Now, suppose that this energy is something like electrical energy. We know that positive repels positive, and that negative repels negative. And further, we know that the positive energy will attract what is called negative energy; and if the two be exactly equal when they combine, of course there will be a neutral state. But in the case of the atoms of matter, circumstantial evidence tells us that the amount of electrical energy which is upon a given atom of matter—if you like to put it in that way—is never the same as it is upon another atom of matter; that is to say, there is always a surplus of one over the other. Thus we may have an atom charged with what we may call *plus* 2 of energy, and another one charged with *minus* 1 of energy. Those two atoms, on coming together, give you a result of energy of plus 1, and this would again be capable of attracting another atom of matter which was charged with a negative energy, and so on. From chemical considerations, it would appear that plus and minus energies of different atoms, as I have said before, are never exact multiples of one another, and that when they are bonded together there is always an excess one over the other. A good example of the energy of the combination of atoms together may be shown by the combination between a gas, chlorine, which we have here, and the metal antimony, and you will see that when the latter, as powder, is thrown into the former, the two combine with an evolution of heat, showing that a vast amount of energy is given out. The chlorine and the antimony form chloride of antimony; that is to say, five atoms of chlorine and one of antimony. [A small quantity of finely powdered antimony was dropped into a jar of chlorine.] You see the evolution of heat between those two; so much, in fact, that the chloride of antimony, as it was formed, was at a perfectly bright white heat. The case immediately before us is the silver salt. Let us experiment with that in a similar way. Into the chlorine I will throw some powdered silver, and I wish you to notice the difference between the results in the two cases. [A small quantity of the powdered silver was dropped into a jar of chlorine.] You see that the combination between the silver and the chlorine only produces a red heat, whereas antimony produced a white heat. In other words, the combination between antimony and chlorine is much more vigorous than the combination between silver and chlorine. If you had to separate the atoms of chlorine from those of the antimony, you would have to use very much greater force than if you had to separate the atoms of silver from the atoms of chlorine.

When two electrified bodies attract one another, they attract one another inversely as to the square of the distance. That is to say, if there is a distance of one foot between them, they attract one another with a force of say—

1. If they are two feet from one another, they only attract one another with a quarter that amount. Supposing atoms attracted one another according to the same law, then of course they being so very close to one another, the attraction would be considerably greater than if they were visibly apart.

But besides this attraction between atoms comprised in the molecules, there also seems to be a repulsive action, into which I will not enter more fully now, because that would be almost beside my subject; but I may say that besides the atoms attracting one another (we will take chloride of silver for instance) when they get within a certain distance of one another, they repel one another, and so there is a continual oscillation between the atoms composing those molecules.

I will try to show you on the screen how we can picture the motion to ourselves. It is only a mental picture, but still it will give us a sort of idea of what happens. [An image was thrown on the screen by means of reflection].

In this circular glass trough of water is floating a little magnet, the magnet being held at the surface of the water by a cork. Passing round this coil, which is large enough to surround the trough, is an electric current from three Grove cells, and if I place it round the cell which contains the little magnet, and not quite on a level with the water, you will find that the single magnet goes into the centre of the water. It is repelled from the sides by the current that is floating round that wire. Well, now, we have here one magnet. Suppose I put another magnet in. The ends attached to the cork have poles of the same name. They repel one another to a certain extent, and yet the force from outside makes them go as near one another as possible. By moving this coil vertically we can make them separate and oscillate, and we can picture to ourselves the way in which two atoms in a molecule may oscillate, and be attracted, and yet repelled one from another. I put another little magnet in, so now there are three; and here perhaps we have a picture of chloride of silver, which I say is composed of one atom of silver and two atoms of chlorine. We can still make them vibrate and oscillate. Here we have a mental picture —at least it is a mental picture to me—of the way in which the atoms of chloride of silver may be made to oscillate. Again I take four, and we repeat the same thing. Here we have a picture of ammonia—three atoms of hydrogen and one of nitrogen oscillating. And so I might go on. I might put five or six or a dozen in, and we might get some idea of the way in which they would all oscillate.

Here, then, we have endeavoured to draw from visible phenomena a mental picture of the way in which atoms of a molecule are vibrating.

I must, however, call to your mind that those magnets are vibrating only in one plane, whereas of course the atoms of a molecule are vibrating, not in one plane, but in space of three dimensions; but anyhow, I hope that you have got into your mind at all events the same kind of mental picture regarding the oscillations or vibrations of the atoms which I have in mine. I think that the case of the magnets is a particularly happy one, because from all the evidence which we have at present we are led to the conclusion that all atoms of matter are really charged with electricity, or what answers to electricity of either one name or the other; that is, either positive or negative.

Now, we will throw a spectrum on the screen. I will call to your recollection what it is. I am now going to send the light of the lamp through this bisulphide of carbon prism, and I need scarcely say that the prism has to play an important part in spectrum photography. The wave length of the red is about one forty-thousandth of an inch, and the wave length of the violet, which is on the left of the screen, is about one fifty-seven-thousandth of an inch. Each ray of light is transmitted in air at the rate of about 190,000 miles in a second. Thus the number of vibrations of the red rays is 500 million millions, and 700 million millions in the case of the violet rays, and this rapid succession of blows batters against anything upon which they fall. The mean violet, I may say, is the photographic light *par excellence*, and we shall recollect that such rays might beat upon the sensitive salt which we expose to it 700 million million times in a second. Therefore, you see, if you give an exposure of the 100th of a second you still have seven million millions of vibrations beating on the sensitive plate, so there is ample vibration to effect any change on the molecule of silver chloride, supposing always the amplitude (or distance of swing) is sufficient. Instantaneous photography will not be complete, I suppose, until you can reduce by a million times.

We may take it that an atom vibrates somewhat in the same way that a pendulum vibrates. Here I have a very rough contriv-

ance to show what I mean. I set the pendulum swinging. Now picture to yourself that the bob is an atom, and picture to yourself, also, a wave of light falling upon that pendulum; if the wave of light be synchronous with the pendulum, it will increase the swing, or, in other words, it will increase the amplitude of the swing of the pendulum. For a rude illustration, suppose I take puffs of my breath as illustrating the beating of the wave of light, and suppose the atom to be at rest; I begin, and I blow; every time I give a well-timed puff to that pendulum, the pendulum increases in amplitude, or swing. But if my breath does not come in unison with that pendulum [blowing irregularly], you see that very soon I should bring that pendulum to rest; in other words, unless the wave of light beats in unison with the atom, the amplitude cannot be much increased. It is true that as long as the breath strikes the bob as it is going away from me the amplitude is increased, but if the puffs are regular and slightly more rapid or slower than the pendulum oscillation, the amplitude must eventually be diminished.

Here we are met with a difficulty, and a very great difficulty. I exposed the plate to the spectrum, and you see the blackening not only was where one wave of light synchronised with that atomic motion, but that there were a great many waves of light, extending from the ultra-violet as far as the blue which affected it. How are we to get over that? That is a difficulty which has puzzled a great many people. I would ask you again to form a mental picture of how that could possibly arise. I do not say that it is the correct way, but all I say is that you can form a picture in your own mind, can conceive of how it could be done. Here, I have another pendulum, but in this case the bob is attached to an elastic band. The time of the vibration of a pendulum depends upon the length of the pendulum. Therefore, if during the time of the oscillation of the pendulum I alter the length, I also alter the rate at which the pendulum vibrates during any instant. I pull down the weight of the pendulum, and at the same time set it swinging, and you will see that during every part of this motion the length of the pendulum is altered so that a great many differently timed puffs of breath might be synchronous with the pendulum. It is not like this other rigid one, where it is of a definite length, but here the length of the pendulum keeps altering. I only ask you to form a mental picture of the way in which such a thing might happen. In this way you can picture to yourself how a molecule might vibrate, and still be synchronous with more than one vibration of light.

Proceeding another step, I may say at once that, to my mind, the theory of the photographic image is well established. I know that there are some people who differ, but in my own mind the formation of the photographic image is not a working hypothesis, but it is a theory. The difference between a working hypothesis and a theory is this—that you adopt a certain idea and say, "I will work upon that idea, and see whether every experiment fits with the idea I have conceived. If it does not fit, then that working hypothesis is no use. I must give it up, I must take some other working hypothesis." As regards the idea of the formation of the photographic image, I think that it has passed from the stage of the working hypothesis into one of a really acceptable theory. It does not follow that everybody will accept it, but still it is an acceptable theory, accepted by most people. I am not going to enter into that very strongly to-night. At the next meeting of the Photographic Society, I propose to deal with it more fully; but, at the same time, I just wish to state publicly, to perhaps a more extended audience than I shall see at the Photographic Society in about three weeks' time, that this photographic image theory—that is to say, the theory as to the action of light upon molecules of silver—is as well established as, at all events, the wave theory of light itself. Now, I am going to show you an experiment which, perhaps, will help to illustrate what I mean by the vibrations of atoms. In this slide I have got a gelatine plate, and I have a little flat iron which has been made warm. It is rather too warm to be borne comfortably. Here I have a phosphorescent plate, which I propose to illuminate with magnesium wire, in order to give an even source of light; I press this flat iron against the back of the plate which is in this slide for a short time. I shall not let the plate cool, but while it is warm I will expose it to the phosphorescent light for about fifteen seconds. The plate is now allowed to become cold, and is developed. If everything has gone right, we ought to have something which shows us that the oscillations of the atoms of bromide of silver (which is the silver salt on this plate) have been given extra amplitude by the action of the heated iron to the back of the plate. I am afraid that I cannot show you the development in the light. [When the develop-

ment had been carried out the plate was shown.]

You now see we have a picture of this flat iron produced by the deeper blackening of the heated part, though the whole plate was given but a short exposure to the light from the phosphorescent plate. I will impress this further upon you. I have here a collodio-bromide emulsion plate. But in this case, instead of heating it by a flat iron, we will heat it by immersion in hot water. Of course a collodion plate is not so sensitive as a gelatine plate. I put it into cold water for a short time to moisten it, and then dip half of it into some nearly boiling water; on withdrawing it, I expose it to this candle, and develop it when it gets cool, which we effect by placing it a short time in cold water. It will be seen that the part immersed in hot water is much blacker than that which was exposed cool. If I heat the plate and allow it to cool and then expose, there will be no effect. The plate will develop normally, for the increased amplitude of vibration will have ceased, and the light will have to perform the same work on each part of the plate. Now, in whatever manner increased amplitude is given, when the cause of the increased amplitude is withdrawn, the amplitude will cease in the same manner. The case before us next was the cause, and it will cease after a very short period, in other words, when the plate gets cold. One of the chief reasons against what we may call the "vibration theory" of the photographic image, namely, that the molecule is unaltered by the action of light, is this—that the increased amplitude would cease with the same rapidity with which it would cease when the hot iron was applied to the back; that is to say, after five or ten minutes the amplitude of the vibrations would come back to the normal extent, a condition which is not fulfilled in the photographic image.

I can illustrate this in a very visible manner. I think you can all see this phosphorescent plate. Now, what is the reason of that phosphorescence taking place? It is that the atoms of the molecules which comprise this phosphorescent material are swinging in a certain rhythm, which gives us the sensation of light. Now, if I apply a hot iron to the back of this plate, I think at once you will see that the image of the hot iron is present. Here is the same kind of action taking place in the one case as in the other.

Now we come to another point, which is a slightly different one, and that is the energy of radiation. I may say that the energy of radiation is a subject on which I could discourse for a good many hours, but here I can devote but two minutes to it. I must try to make it as clear as I can. I hold in my hand a little instrument which is called a thermopile, which you see has a narrow slit which could be narrowed to any degree of fineness; attached to it is a screw motion, which will make that slit travel along the base of the instrument; beneath that slit are some thermo-electric couples. It is not my business to enter into how they are made, but still we know that, when thermo-electric couples are heated, an electric current is generated sufficiently strong to cause the needle of a galvanometer to deviate; and the amount of energy of radiation which falls upon the face of the pile can be measured by the deviation of the galvanometer needle, from the energy heating the lampblack at the junction of the couples. In a great many experiments which were made, this thermopile was caused to travel along the spectrum by the screw motion, and at every part of the spectrum at distances of, say, a quarter of a turn or half a turn of the screw, the amount of deviation which was given to the galvanometer needle was read off. By that means we are able to compare the energy existent at different parts of the spectrum. The spectrum used was that of the electric light, the comparative energies at different parts of its spectrum I have in the diagram—at five turns of the screw we have the end of the red, and at different turns we have the yellow, the green, the blue, and the violet; whilst from five to twenty we have the dark rays which lie below the red, and with which we are not to deal to-night at all events. The energy, I may say, being measured by taking the amount of the deflection of the galvanometer needle, you will see that the dotted line divides the energy area into two parts.

On measuring this area of the curve in which lie all dark rays, and the area of the curve for the visible rays, it will be found that, roughly speaking, the energy of the latter rays are about half that of the former. But for photographic action we do not have anything like that amount. The red rays for ordinary photographic work are useless; and why that is we shall see by and by. We will say that the photographic action stops at the blue, and we find that the total energy of radiation which is used for photographic purposes in

the electric light, is only about one-hundredth part of the whole energy of radiation. The remaining ninety-nine parts are wasted as far as photography is concerned, except in so far as they heat up the molecules in the same way as the flat iron heated up the molecules on the photographic plates. The other curves show the energy of incandescent lamps. You will see that they have very little of what is called actinic power; that is to say, they have very little blue ray at all compared with the arc light. In the lowest curve we have a lamp at only a yellow heat, the middle curve being that at a white heat, and you will notice the enormous difference there is in the energy between the two. The energy of the middle curve, which measures the total energy of radiation from the incandescent light, is about twelve times that of the visible power. Yet, when you have to measure the photographic part of the spectrum, you will see that it is only about eighty. That is to say, supposing you have a filament of an incandescent lamp which is one-hundredth of an inch wide and half-an-inch long, then if you take an arc electric light and cut off from the glowing positive pole the same area, the photographic value of the one, area for area, is about eighty times that of the other. [A spectrum was thrown on the screen.]

I will ask my assistant to put in front of the slit something which I showed you at my last Cantor Lectures, and which I dare say you have forgotten all about. That something is a film of the same silver salt with which I photographed the spectrum at the commencement of the lecture. You see that it cuts off all the violet, and well down into the blue. I want to show you that the colour of the photographic spectrum is perfectly different from that which the human eye can see. I wish to show you a little device by which, perhaps, I shall be able to give you an idea of the integrated colour. A tolerably bright spectrum is on the screen of the camera; I raise the screen so that the spectrum falls on a lens placed a little beyond it; and if we had time, I dare say that we should be able to get a screen placed in the focus of the second lens, so that the recombined colours would form a white patch, without the slightest tinge of colour. We have got a white circle, however, which is sufficient for our purpose, though at one margin there is a very narrow red fringe to it. [A white patch about 6 inches in diameter was formed on a transparent screen about 6 feet away rom the camera.] In the place where the coloured spectrum is in focus, I place a horizontal aperture, about $\frac{1}{4}$-inch wide, and by a little arrangement I can, by strips of card, cut off any colour I like from falling on the collecting lens, so that it recombines only the remaining colours.

You remember that the photographic spectrum does not extend as far as the green, ordinarily speaking, so now I cut off all rays as far as where the photographic spectrum begins, and you can see the colour of the light, which is really useful for photography. It is a sort of sea-green colour. If I were to take that light, and pass it through a slit and a prism, you would soon find that the whole of that spectrum would be photographically active, because all the light which is not photographically active has been cut off. I shall have to revert to this in my next lecture.

I will show you one more method of recombining the photographically effective colour disc; that is by taking the ordinary disc, and cutting out the red and orange. We have, then, only the green, the blue, and the violet; and those, when they are combined together, ought to give you pretty nearly the integration of the colours which are ordinarily photographically active. I will ask my assistant to spin it in front of the lantern. [The instrument was rotated.] I do not know whether you can all see the colour-chart which I hold in my hand, but those who can will see that the colours, when placed in the blue-green light, appear totally different from what they did in the whiter light. The yellows are much deepened, and the reds are much blacker.

I will ask now to have the spectrum thrown upon the screen once more, and we will again pass this colour-chart through the spectrum. The colours are very pure for pigments. I think that it is the finest colour chart of the spectrum which I have ever seen. It is one prepared by Professor Piazzi Smyth, and appears in his Madeira spectroscopic observations. Notice that the blue appears perfectly black when the chart is in the red, the red at the left hand being brilliant. Passing it into the yellow, the yellow is vigorous; the blue is black, and the red undimmed. Upon my passing it still farther on in the green, you will see that the red is blacker, and the orange is blacker, whilst the yellow still keeps its colour, and the blue begins begins to get more bright. Passing it still farther on into the violet, we see that the yellow is now perfectly black, the red has gone, and the blue begins to shine out.

Passing still further, you will see that the blue still shines out, but is less intense, all the other rays appearing black. Upon my passing it again rapidly through, you will now be prepared for the changes that take place. In this lantern, which has been used to form the spectrum, the light passes through a slit. The slit, you see, is perfectly straight, with parallel edges. Now comes the question, "Is it necessary that light, in order to be decomposed into a spectrum, should be passed through a slit of this description, or what shapes may it be allowed to take?"

I propose to try to answer this query in an experimental manner a little. First of all, we will see what the effect will be if we use no slit at all. You see that the colours are not pure. I replace the slit, and you will see at once that we now have, not the various colours light overlapping, but a tolerably pure spectrum. Now let us take a slit of another shape—a zig-zag slit; and here we have another form of spectrum delineation of the rays. Placing a metal in the arc, the bright lines due to the vapour flash, and, it will be seen, take the zig-zag form of the slit. There is, then, no particular reason for using a straight slit, except convenience. Then, again, I may take a ring slit, and to test its value we will put a little silver in the arc to show you. I am not simply showing this as a pretty experiment, but I want to show you that such a slit is absolutely useful in photography, the spectrum of silver now on the screen shows rings of different coloured rays. It is a very pretty spectrum. This form of slit is extremely useful in one branch of spectrum analysis.

You are perfectly aware that, during a total eclipse, the body of the moon covers the sun; but that there are seen beyond the dark moon certain red protuberances which belong to the sun, and are known as "prominences." It has been the work of astronomers to determine the composition of those protuberances, and also to form a definite idea of the corona of light which surrounds the body of the sun, and can only be properly seen during a total eclipse. The picture on the screen is a representation of the total eclipse of the sun which took place in Egypt in 1882. It is a negative picture, and of course the dark halo which you see around was seen as a bright halo, and the white disc is the black moon. On the left-hand bottom corner you may notice the comet which was discovered during the eclipse, and which received the name of Tewfik, after the Khedive of Egypt. Round the disc of the moon are little prominences. Those prominences are vastly more bright than the corona itself, which is the halo extending some distance round the sun. Thus we have a bright ring of light round the moon surrounded by a feeble light. The former, when viewed by means of a lens in front of which a prism is placed, shows rings of colour composing these prominences, and of course these rings can be photographed.

I now show a transparency of a photograph taken in Egypt by means of the slitless camera, from which much valuable information has been derived.

The ring slit was used by an Italian astronomer about 1870; but the eclipse in Egypt was the first time it was entirely successful for photography.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

GROUP I.—AGRICULTURE, ARBORICULTURE, AND HORTICULTURE.

By D. Pidgeon.

It is perhaps a little unfortunate that intending exhibitors of agricultural machinery were warned, before making their entries for the Inventions Exhibition, that the space placed at their disposal was extremely limited. The Council was no doubt somewhat alarmed lest the six or seven thousand implements annually filling some miles of shedding at the Royal Agricultural Society's Show should demand admittance to the narrower galleries of South Kensington. But the announcement in question resulted, in the first instance, in such a paucity of entries in Group I., that the rule was wisely and timely relaxed, and, in the result there has been brought together at the Inventions Exhibition a collection of farm machinery and farm appliances, ample for illustrative purposes, and extremely typical in character.

The total number of exhibitors in this Group, which includes agriculture, horticulture, and arboriculture, is somewhat less than 120, as against an average of 380 annually present at the Royal Agricultural Society of England's Show. Scarcely a dozen out of the 120 exhibitors are foreigners, and they, with certain notable exceptions in favour of America, show nothing novel or useful.

Referring, in the first instance, to agriculture as the most important branch of the Group under review, the visitor finds the South Court entirely

occupied by a varied collection of implements, displayed with that remarkable effectiveness which agricultural engineers have learned in the school of the Royal Agricultural Society's annual show. It will facilitate a proper appreciation of the machinery in question if I begin by classifying it into prime movers, tillage, field, and barn implements, dairy, ensilage, bee-keeping, and chicken-hatching and rearing appliances, instead of noticing the miscellaneous contents of each stand individually.

Referring in the first place to prime movers, Messrs. Richard Garrett and Sons, jointly with Messrs. John Fowler and Co., of Leeds, must take credit for having introduced the compound steam-engine to the farmer. Portable engines, with variable expansion gear, although realising great economy of fuel, are much too delicate for the rough usage of farmers' engine-drivers. Hence, single-valve engines, burning far more coal than is necessary for the work done, are still the rule on the farm. The compound engine, on the other hand, while more economical of fuel than the best expansion engine, has a perfectly simple valve-gear, and, although at present regarded with some prejudice on account of its second cylinder, will undoubtedly make its way to the front in the near future, as the simplest and most economical prime mover yet offered to the agriculturist.

Messrs. Aveling and Porter show a traction-engine, fitted with driving wheels, whose tires are hung on strong spiral springs which, acting either in tension or in compression, relieve the heavy machine they carry from the shocks and strains which it necessarily suffers in travelling over bad roads.

Among a large collection of tillage and other implements, Messrs. John Fowler and Co. exhibit three engines of considerable novelty and interest. 1st. A road locomotive which, having all four of its wheels drivers, gives greatly increased adhesion and hauling power. The engine shown weighs 11 tons, of which 6 tons rest on the hind, and 5 tons on the leading wheels, so that, under ordinary circumstances, little more than half the weight of such a locomotive would be utilised for tractive purposes. Under the new arrangement, the leading wheels, while remaining free to turn right or left for the purpose of steering, are connected by means of a pitch chain and a system of differential gearing with the engine shaft, and are thus caused to become drivers, no matter in what position the action of the steersman may place them. 2nd. A finely designed "undertype" compound engine, fitted with an automatic expansion valve, controlled by a high-speed horizontal governor. 3rd. A "flexible" locomotive engine for narrow gauge and farm railways. This engine is a surpassingly clever adaptation of ways to means. Narrow gauge roads, roughly and rapidly made, are dangerous at all but the most moderate speeds to the ordinary locomotive. Such roads have, however, to be traversed without any hope of the permanent way being improved up to the needs of the locomotive. Under these circumstances, "taking the bull by the horns," Messrs. Fowler have constructed an engine which, whether in regard to the driving or trailing wheels, is "flexible" both vertically and laterally, and with the result that fairly high speeds may be obtained on the worst roads, without excessive wear and tear of the plant.

Messrs. Ransome, Sims, and Jefferies (Limited), exhibit their straw-burning engine, which, a novelty ten years ago, is now in use in every part of the world where grain is grown and fuel scarce or wanting. The apparatus consists in a feeding box, like that of a chaff-cutter, placed in front of the furnace door, and furnished with a pair of feeding rollers driven from the engine shaft. Straw is laid in the box, and delivered by the rollers into the furnace in a thin continuous stream.

The consumption of straw-burning engines is from 15 to 18 lbs. of straw per horse-power per hour, while the calorific value of straw is as 1 to 3½ compared with coal. Hence, taking the local values of coal and straw into consideration, it would cost three or four times more to burn the former than the latter in countries such as Russia and Hungary. Upon the treeless steppes of these countries, therefore, as in some parts of Italy, in South America, New Zealand, Mexico, and California, the straw-burning engine has made it possible, for the soil to be ploughed, the grain harvested, thrashed, and converted into flour by energies derived entirely from the combustion of the straw furnished by the crop itself.

Passing from prime-movers to field implements, the first machines to challenge attention are the self-binding reapers, of which Messrs. W. A. Wood, Hornsby, McCormick, Howard, the Johnston Harvester Co., and Samuelson and Co., all show examples. These implements are of such recent introduction, and of so important and interesting a character, that a few moments may, perhaps, be profitably spent in tracing their origin and history.

In 1826, the Rev. Patrick Bell invented a reaping machine in which the usual reciprocating knives were supplemented by a endless travelling web, or apron, upon which the cut grain fell, and by which it was carried to the side of the machine and delivered in a continuous swathe. This, although the Scotch minister could not foresee the future, was the first step towards the modern self-binder.

In 1847, Mann, of Clinton, Ohio, added to Bell's apron a second set of webs, which carried the cut grain into a box placed behind the driving-wheel, whence it was discharged at intervals in sheaves. Watson and Renwick, of Chicago, patented the first true sheaf-binder in 1853, adopting the Bell and Mann webs, but doubling that of the last inventor, and carrying the cut grain, between two moving aprons, over the driving-wheel; binding it automatically with wire, and discharging it, so bound, in sheaves.

About 1863, Burson, another American, constructed a machine to bind the grain as it was received from the Bell, Watson and Renwick, and Mann webs, the binding mechanism in this case being operated by hand.

None of the devices in question, however, proved successful in practice, and, upon the introduction, about this time, of the self-acting sheafing reaper with revolving rakes, the subject was allowed to drop, and slept for some years.

In 1867, Walter A. Wood, working in connection with an inventor named Lock, constructed a wire-binding reaper, which ultimately became a practical success. Two of these machines were put into operation in 1870, and in 1873, one was shown, for the first time in Europe, at the Vienna Exhibition. This binder was manufactured on a large scale by Wood, between the years 1875-79, and other American manufacturers having busied themselves actively with the same problem, some 20,000 wire-binders, by various makers, were sold in the States during the five years in question.

But, presently, there arose an outcry, as well from American millers as farmers, against the use of wire as a material for binding; and, as a result of this complaint, the Johnstone Harvester Co., in 1878, and Wood and Holmes in 1879, introduced string-binding machines. Two years later, in 1881, Appleby, another American inventor, introduced a third string-binder, which came rapidly into favour, and has now become the pattern machine for all the leading American makers, except Wood, and for all the English manufacturers who have followed the lead of their American rivals in adopting the self-binding system.

The Wood-Holmes machine may, therefore, be considered as the pioneer string-binder, although it is the child of preceding wire-binders, and the successor, in time, of the Johnston string-binder of 1878, a bantling which was ultimately forsaken by its parents in favour of the Appleby reaper. The latter machine, manufactured under license by all the English reaper makers, has been modified this way and that, to suit the exigencies of our heavier crops, but without changing its ingenious original features.

No other field implements present so much of interesting novelty as the self-binding reaper. The mowing machine has long been a household word with all advanced farmers, while haymakers and horse-rakes are equally well known. Excellent examples of all these harvesting machines may be seen on the stands of Hornsby, Howard, Ransomes, Nicholson, and others, but do not call for special remark.

Two new field implements, for use with steam cultivating tackle, are, however, to be found at Messrs. John Fowler and Co.'s stand. One is a plough for ditching purposes, arranged on the balance principle, one end of the framing carrying blades by which the ditch is formed, while the other end carries other blades, by which, at the second passage of the tool, the ditch is cut to its full depth of 2 ft. 6 in. The second novelty consists of a combination of cultivator, roller, and harrow, each of the three sections acting on the ground successively.

Among barn implements, Messrs. Ransomes, Sims, and Jefferies exhibit an apparatus for chopping, bruising, and softening straw as it issues from the steam thrashing machine. This invention is of value in hot countries, where, hay not being grown, cattle are fed almost exclusively on straw. This, being much harder than that of colder countries, cannot be advantageously converted into fodder by a chaff-cutter in the usual way, because the sharp edges of such food stuff as is thus produced cause serious injury to the mouths of animals to whom it is given. Until the introduction of the apparatus in question, therefore, it was found impossible to use steam thrashing machines in certain countries, the farmer being obliged to thrash by the primitive method of driving mares over sheaves scattered on the ground. Even so, the crushing and softening of the straw resulting from continued treading was not performed so effectively as by the apparatus under review.

Messrs. J. and F. Howard exhibit an interesting adaptation of the sheaf-binding device employed in the reaping-machine, for the purpose of trussing and binding straw as it issues from the steam thrashing machine. Loose straw is one of the most difficult things to handle in a cleanly and economical manner, and in the neighbourhood of great towns, where it is in strong demand, as well as in the north of England, where the farmer is perhaps neater in his work than elsewhere, the straw is frequently trussed and bound by hand on leaving the straw shaker. Messrs. Howard's apparatus renders this operation automatic, the thrasher delivering its spent straw in a succession of neatly bound sheaves, which can be easily dealt with by the elevator or the fork.

Flour mills stand somewhat apart from the divisions into which agricultural machinery has been classed at the outset of this report, but milling is, none the less, one of the most important features of Group I. It is, on this account, much to be regretted that, saving Mr. J. Harrison Carter's roller mills, there should be scarcely another exhibit of flour-grinding and dressing machinery of any importance at South Kensington. Mr. Carter's machinery has, however, a special interest of its own, since it represents a probably imminent and complete revolution in the present theory and practice of flour-milling.

About twelve years ago, American and Hungarian millers first began supplying this country with flours that were immensely superior to those produced even in the best English mills. For some years the British miller shut his eyes to the fact that he was being gradually beaten on his own ground by foreign competitors, but, at length, there came a time when he could no longer ignore the increasing dangers of his commercial position.

Mr. Harrison Carter, himself originally a miller, taking advantage of a conference held in London, to consider the crisis thus created by Yankees and Austrians, promoted a trip, and finally conducted a representative body of English millers to Buda Pesth, for the purpose of inspecting certain Hungarian mills whence these fine flours came. The lessons then learned resulted in the introduction of the machinery now under review, but these lessons, in order to be generally understood, demand at least a short description of the ordinary milling process.

This consists in passing the grain between a pair of millstones, set together so closely as to crush, at one operation, all the interior of the wheat berry, while the skin, or "bran" is, for the most part, spread out into flat flakes of various sizes. The bran and coarse meal, or "middlings," are next separated by "dressing machines" from the flour, which is, however, always more or less coloured by the presence of numerous bran particles that, being reduced to the fineness of flour between the stones, have passed through the screens of the dresser with the meal.

At Buda-Pesth the party of investigators found that the high-class flours giving them so much trouble in the market were obtained under a system of "gradual reduction," and from "roller-mills" instead of from millstones. In the process of "gradual reduction" by rollers, the wheat is led, in the first place, between a pair of fluted and differentially speeded iron rollers, which simply crack the grain without grinding it. Such dirt and dust as this first cracking of the berry sets free is then removed by dressing. The cracked grain next passes between a second pair of grooved rollers, set more closely together, which break it again, and the resulting meal is sifted into what is called "semolina," or fragments of the wheat-berry, and "break-flour." These operations are repeated many times, always with successively closer rollers, until the wheat-berry has been entirely broken up into bran, "semolina," and such "break-flour" as accompanies the various crackings.

The particles of semolina and bran which are, of course, of very various dimensions, are next sized or graded, by sieves, into a number of samples. The bran is blown out from each of these by currents of air, which are gentler or stronger as the meal is coarser or finer, and the purified products are finally crushed between a pair of smooth iron rollers. Flours of the highest quality are thus obtained, and these, coming from America and Hungary, have set the English miller wondering whether or not the millstone, after an existence longer than human history, is not itself about to pass away just as the flail has already done, and as the sickle is doing.

Turning now from flour to milk, it is to be remarked that the handsome dairies forming so important a feature of the Health Exhibition are represented at the Inventions only by the exhibit of the Aylesbury Dairy Co., and that this is illustrative not of the complete modern dairy, but only of the Danish cream separating machine.

The separation of cream from milk by means of a centrifuge has been thoroughly familiarised to the public mind since the introduction of the Laval separator in 1879. It is now well known that if whole milk be introduced into a rapidly rotating vessel, the milk, being heavier than cream, is thrown outwards to the circumference of the whirling vessel, while the lighter cream forms an inner circumferential stratum, resting upon the milk. Separation once accomplished, it is easy, by means of suitable collecting appliances, to deliver milk and cream continuously into separate receiving vessels.

A very interesting piece of accessory apparatus has been recently added to the Danish separator, having for its object the rapid testing by the dairyman of such milk samples as he receives from farmers.

A number of metal cases, suitable for the reception of phial bottles, are pivotted to the axis of the revolving centrifuge. Each bottle contains a sample of milk, and, upon putting the machine in motion, all the metal cases fly outward, like the governor balls of a steam-engine, under the influence of centrifugal force. The milk in each phial immediately separates itself into a far and near stratum of milk and cream respectively, and on removing the bottles, which are graduated for the purpose of measurement, the per-centage of cream in the various samples may be ascertained at a glance.

The subject of ensilage makes somewhat slow and doubtful progress, and, so far as the Exhition is concerned, the study of its principles has been generally neglected by exhibitors, who have busied themselves in devising a number o somewhat obvious plans for the purpose of compressing crops, whether in the silo or the rick.

Mr. James Howard alone appears to have grasped the idea that the purpose of a silo, like that of a jam-pot or meat-can, is merely to prevent movements of air among the material it contains. These movements can only be partially prevented by the compression of stuff which is liable to become locally and capriciously warm by fermentation. Mr. Howard treats the contents of his silo just as a housewife does bottled fruit. An air-tight chamber, whether of brick or any other suitable material, is filled with the cropping to be saved, and then covered in with a lid, whose reflected edges dip into a gutter filled with water, for the purpose of forming an air-tight joint. This plan is now no mere experiment, and the silage from one of these closed chambers is perhaps the best of any that has yet been exhibited.

Several plans for pressing ricks, and thus converting them into quasi-silos, are shown; but if damp hay can be saved merely be weighting down ricks, a much more economical and effective way of procedure would be to follow up the mowing machine in the field with some powerful hay compressor, such as the Dederick press. This ma-

chine is capable of forcing a ton of hay into a ton measurement, representing a vastly greater amount of compression than could possibly be obtained by any rick-pressing device. Its use is common in the hay-fields of Western America, where, however, the hay being got very dry, and the object aimed at is merely to put the forage at once into a handy and marketable form.

Messrs. Neighbour and Son, and Messrs. Baldwin, show some excellent bee-keeping appliances, well worthy the careful study of apiarians, amateur or professional, but want of space forbids more than a passing notice of a single point of modern bee practice. The energy expended by bees in producing wax is out of all proportion greater than that which is required to make honey; and hence it is a matter of high economical importance that bees should have as little wax-making to do as possible. The modern bee-man, therefore, supplies his bees with comb boxes, which are already furnished with a central film of artificial wax, upon whose hexagonally indented surfaces the bees build up their cells on either side. When the cells are full, the box is placed in a simple centrifuge, and the honey extracted by centrifugal force, just as water is wrung from clothes in a large laundry. The comb, emptied of honey, is then returned to the hive, where the workers may fill it many times, without any expenditure of energy on wax-making.

Little can be said of such chicken-hatching and chicken-rearing apparatus as is exhibited at the Inventions. This is to be regretted, in view of the fact that the industry of French farmers has put them in possession, within a few years, of a trade in eggs and poultry worth at least £8,000,000 per annum. France, indeed, pays her national coal bill with eggs, of which she sends us £2,000,000 worth a year, that being only one-fifth of her total annual production. This valuable business is the child of minute care applied to the use of the hydro-incubator and artificial mother, a care which it would be satisfactory to find emulated by the smaller farmers of Great Britain.

Arboriculture and horticulture, the remaining branches of Group I., have an interest subsidiary to that of agriculture, but, nevertheless, present some points for remark.

Referring, first, to arboriculture, a steam tree-felling machine, exhibited by Messrs. Allan, Ransome, and Co., is a noteworthy example of the persistence with which the engineer now invades every province, even the most remote, of industry. Here is a complete set of apparatus, easily moved and managed by one horse and four men, and capable of cutting down a forest while the woodman is "laying his axe to the root of the tree." Several hundreds of these steam woodmen are, it is said, at work at the present moment in various parts of the world.

And, just as the modern world cannot wait while the axe is plied, so it is impatient of that tedious process known as "seasoning," which used to follow slowly upon timber-felling. The railway, telegraph, and road-making engineers now demand that their wants of sleepers, poles, and paving blocks shall be supplied as soon as known, and the pickling of timber has, consequently, become an immense industry, one of whose latest improvements is shown by Messrs. Burt, Boulton, and Haywood.

Creosote, the commonest of the timber preservatives, is ordinarily forced into the pores of sleepers, piles, and other scantlings, by placing these in a closed chamber, exhausting the air, and then admitting the antiseptic fluid under heavy pressure. But the vessels permeating woody fibre contain much more water than air, so that, even after the removal of the latter, the creosote still finds its entrance into the timber barred, and only a comparatively small quantity of pickle is consequently taken up.

Taking advantage of the different boiling points of water and creosote, Mr. Boulton has lately patented a plan whereby the creosote is made to enter the wood in the vacuum chamber at a temperature above that of boiling water, thus vaporising the moisture contained in the timber, and making room for the entrance of the preservative fluid.

The Horticultural Section of the Exhibition is chiefly remarkable for the number and variety of the efforts now being made to introduce an effective system of dry glazing, applicable to conservatories, &c. Among these, those of Messrs. Rendle, and of the British Patent Glazing Company, are perhaps the most noteworthy; while Messrs. Foster and Pearson's well-considered plant houses, frames, &c., glazed in the usual way, are worthy of study by the gardener. A system of glass walling, although not new, is an interesting feature of the horticultural exhibits, while, in quite another direction, Beckett's folding boxes for the transmission of flowers by post are trifling but meritorious little novelties. Among lawn-mowers, some very light draft American machines are shown by Messrs. Lloyd, Lawrence, and Co., while Messrs. Ransomes and Co. exhibit, for the first time, a clever edge clipper which promises to prove a valuable adjunct to the lawn-mowing machine.

The number of visitors to the Exhibition for the week ending Tuesday, 28th inst., was 149,527. Total since the opening, 1,766,050.

Correspondence.

HAY-FEVER.

A correspondent writes:—Dr. Poore's Cantor Lecture, No. III., and his account of the experiments and researches of Mr. Blackley, have been most carefully read by a "hay-fever subject," who is deeply disappointed to find that the researches are not

followed up by so much as a single hint as to how to stop or check this troublesome malady. It cannot be denied that one hears a great deal more about "hay-fever" than was the case a few years since, and that the complaint is becoming far more general than it used to be, it being now very prevalent with, and correspondingly inconvenient to, a large number of the professional class, who are obliged, during the most busy part of the London season, to struggle on, seriously handicapped by this formidable foe. Careful observations fully bear out the germ theory as advanced by the lecturer, not only the presence of the germs, but an agitation or disturbance of the germs being a cause of the malady. For instance, upon a not very sultry day, three or four hours in the country have been spent without inconvenience, but on the same day, half-an-hour in an express train has sufficed to bring on the most aggravated symptoms; in the same way, in town, a week or two has been passed without trouble, but a couple of hours at an open-air exhibition, in the same locality, with a moving crowd stirring up dust and pollen, have produced a violent attack.

As a further instance of the correctness of the germ theory, I may mention the case of a patient who went by sea from London to Southampton for the purpose of being for a short time free from hay-fever; the result was perfectly successful all through the voyage, with the exception of a short period which was passed close in shore, the wind blowing off the land.

The only check to hay-fever appears to be first, sleep; second, freedom from pollen; the so-called cures, such as snuff or other application to the nostrils, being perfectly useless. The above conditions combined effect an almost miraculous cure, as has been proved by sleeping for a short period under the protection of carefully wetted cloths through which the air is as it were filtered, or more certain still, a night spent at sea. These remedies are not always within the reach of the business man, especially in London, there being great difficulty in getting out to sea and back again without setting up a fresh attack. Experience shows that if the attack is once stopped, a moderate amount of exposure to germs may be risked without setting it up again. The conclusion to be drawn from this is, that it would be worth the while of some enterprising individual to establish a "hay-fever cure." The arrangement would be extremely simple, neither more nor less than a series of sleeping apartments into which nothing but air deprived by straining through wet flannel of all germs, and possibly cooled down to about 55° or 60°, could penetrate. Upon a large scale, such an establishment could be easily worked at a profit, in connection with any of the large Turkish baths or other similar establishments in town.

Tha beneficial effects of low temperature have been conclusively proved by subjecting a hay-fever patient to the action of one of the preserving chambers in a cold store for meat. The remedy, however, was too violent to be generally adopted, but a temperature of 50° would, no doubt, suffice, and could be, of course, borne without inconvenience in the hottest summer.

It is suggested that perhaps the ventilation of this subject in the columns of the Society of Arts *Journal* may lead to an experiment being made, which may result in the establishment of a refuge for hay-fever subjects. This, if successful, might be followed up by a railway carriage similarly fitted to enable such persons to travel by rail in the hottest weather.

Obituary.

Sir Moses Montefiore.—Sir Moses Montefiore, who died on the 28th inst., at the mature age of 100, had been a member of the Society of Arts since 1876. He was born in Leghorn, on the 24th of October, 1784, the grandson of an Italian merchant who had settled in England. He was established in business as one of the twelve Jew brokers at that time permitted to practice in London, and, as is well known, accumulated a large fortune. In 1824, he retired from business, and devoted himself to charitable objects, the chief object of his life being the improvement of the condition of Jews in the East. In 1834 Mr. Montefiore became Sheriff, and as Sheriff was knighted by the Queen. He afterwards received a baronetcy. The completion of his hundredth year in October last attracted a great deal of attention.

General Notes.

Reduced Production of Wool in Germany.—The *Wochenschrift für Spinnerei und Weberei* states that the number of sheep in Saxony has fallen from 371,989 in 1861, to 149,037 in 1883. In the whole of Germany there was a reduction of 33 per cent. between 1873 and 1883.

Mechanical Telephone.—A new form of mechanical telephone was shown in operation between Ludgate-circus and the Temple-bar end of Chancery-lane. The apparatus is the device of Messrs. A. A. Knudson and T. G. Ellsworth, and is a modification of the string telephone, with wire for the string (as employed by Mr. W. J. Millar, of Glasgow, some years ago), and plaited willow chips for the diaphragm or tympan. The plaited willow tympan is found to give very good effects. It is shielded by a wooden cover or mouthpiece. The call consists in tapping this wooden cover. In the recent trials, says *Engineering*, the ticking of a watch was heard distinctly across Ludgate-circus, and whispering all the way from Chancery-lane.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

SOCIETY OF ARTS EXAMINATIONS.

The Programme for 1886 is now in the press, and will be issued shortly. The Examinations will be held on the 12th, 13th, and 14th of April. The only alteration in the scheme is the removal of "Sanitary Science" from the list of subjects, an examination in Hygiene having been recently instituted by the Department of Science and Art. The Practical Examination in Vocal and Instrumental Music will be held at the Society's House in May.

Proceedings of the Society.

CANTOR LECTURES.

PHOTOGRAPHY AND THE SPECTROSCOPE.

By Capt. Abney.

Lecture II.—Delivered April 27th, 1885.

In my last lecture, I left off with the use of the slit in the spectroscope, and I showed you, I think, that under certain circumstances the slit which had the form of a ring was useful, having previously demonstrated that it was not necessary that the slit should be straight, but that it was most convenient that it should be so. I will next deal with the subject of the prism. We know that prisms are employed to separate the different coloured rays, as each colour is differently refracted as it passes through the prism, and it is this difference in the index of refraction between the red ray and the violet ray which gives the amount of dispersion in forming the visible spectrum. Of course, if we go beyond the violet, there are invisible rays, while again below the red there are also dark rays, which also have their indices of refraction, but I wish to show you the influence that the material of the prism itself has on the dispersion of the visible spectrum.

I have here a prism of 60° built up of six or seven different triangles of glass. It is apparently homogeneous, but when we pass light through it we shall find that it is anything but homogeneous; in other words, the different portions are differently refractive. The different portions of the prism are all glass, as I have said, but of different densities, and the denser the glass, the more are rays refracted, and the greater dispersion between the red and violet there is. [A slice of light was passed through this built-up prism, and the different spectra thrown on the screen.] You will notice, by the spectra on the screen, that the length of the top spectrum between the red and violet is much smaller than that of the bottom spectrum. The glass which gives the dispersion to the latter is much denser glass than that which gives it to the former. Practically speaking, therefore, we may say the denser the glass the greater refraction, and the greater dispersion there is. For most purposes in spectroscopy, it is as well to use as dense a glass as possible in order to get the maximum amount of dispersion. I will now combine three prisms together, two of a light glass, and one of a denser, and we get a combination, in which, although the main beam will pass straight on to the screen, yet the presence of dispersion is also shown by the formation of a spectrum. This is an example of what is called a direct vision prism. The spectrum is given by the differences of the refractive indices for each ray in the two kinds of glass. For some purposes this kind of compound prism is very useful, and particularly for lecture experiments, but, as a rule, for photographic purposes I should not recommend it, on account of the internal reflections which take place between the different surfaces of the glass, though they are cemented together. You must recollect, wherever there is a difference in density between two media, in other words, a difference in the refractive indices, there is always a certain amount of reflection, and those reflections, being white light, are rather apt to fog the plate, and give you false notions of what you get in the photograph.

We come now to a much more important point with regard to the spectrum, and that is, what is the best material to use. In those prisms which I have already shown you, the material was glass. Now glass is, comparatively speaking, a mixture of materials, and has no definite chemical formula; but when we come to a material which has some definite chemical formula, we find that, as a rule, it has certain properties which are invaluable in certain forms of spectroscopy, more particularly when the photographic plate has to be brought into requisition. Quartz is an example of this; it is a definite compound of silicon and oxygen, and we find that it has certain definite advantages which are not to be found in glass prisms. The dispersion is not quite so great as it is with glass, but, on the other hand, it lets through rays which are cut off completely by glass, as I hope to show you on the screen. This quartz prism has very well-worked faces, and we will send a beam of light through it, and then proceed to investigate its behaviour. [Spectrum thrown on screen.]

I may further say, in reference to this, that the condenser in that lamp is quartz, the lens is quartz, and the prism itself is quartz, so that we are dealing with nothing but quartz. Now, the question comes, is there any advantage to photographers in using such a material as quartz. Let us first see the extent of the spectrum. By placing a card which has been washed over with quinine in the ultra-violet part of the spectrum, you are able to see these ultra-violet rays glowing with a pale blue light, and you will notice to what a great length these rays reach beyond the ordinary visible point of the spectrum. Now, by placing a piece of glass in front of the slit, you will see that the ultra-violet spectrum is very much shortened; in other words, the glass has absorbed these rays. I may repeat the experiment with a card which has been brushed over with paraffin oil, and the same result holds good.

I have here a photograph of the electric arc taken in another manner, to which I shall have to direct your attention presently. The ight in this case has to pass through no glass whatever. The spectrum was taken by a diffraction apparatus; for the top part of the spectrum a glass was interposed in front of the slit, and we see the difference there is in the spectra, owing to the use of glass in one case, and not in the other. The glass apparently cuts off many useful rays; but I will now draw your attention to the solar spectrum taken in the same way, in which there has been a glass placed in front of the slit for one spectrum, and not in the other. Both spectra, practically, reach the same limits. We now can answer as to whether it would be advisable for photographers to use quartz lenses for ordinary photographic purposes or not. Recollect that every ray of light you saw fluoresce on the screen is useful for photographers when they are using a light such as we have in the electric light. You will see, then, from that, if the electric arc light was usually employed, all those rays which are cut off by the glass could not be utilised by them, and, therefore, there would be so much power wasted. Now photographers, as a rule, do not work with the electric light, but with sunlight; we have seen that in the solar spectrum taken under similar conditions, the glass practically cuts off none of the ultra-violet rays; the atmosphere of the earth, or of the sun, or both, cuts off the extreme ultra-violet rays before the light reaches us. We therefore come to the conclusion that, so far as photographic work with sunlight is concerned, there would be no advantage in using a quartz lens over the ordinary photographic lens. Some years ago, Mr. Claudet made an agate lens, which he considered would give him greater advantages over the ordinary photographic lens, simply because he could utilise the ultra-violet rays, but I think you will see from this there is no advantage in using such a lens. Remember, however, if you are photographing the spectrum of the electric light, or using it for illuminating a sitter, there is a very great advantage in using quartz. We may use another definite chemical compound in the shape of Iceland spar. I have here a very beautifully worked prism of Iceland spar, which has a definite composition of calcium and carbon, and I dare say that we shall reach very nearly to the same ray limit as we did in the quartz experiment. Iceland spar holds an intermediate position between quartz and glass. It was with such a prism as that that Dr. Huggins took his famous star spectra, and I thought it might interest you to throw one or two of these on the screen. They are very small, but the definition is very beautiful. Many of the black lines in these spectra indicate, probably, hydrogen. It remains to be seen whether Dr. Huggins has attained any advantage in using Iceland spar instead of glass, for if the ultra-violet stellar light is absorbed, as with sunlight, no advantage would be gained. I may

mention that he gives the composition of the stars by reference to the spectral lines of well-known elements.

One more point is this: Would it be advantageous to use a mirror instead of a lens? There is a great deal to be said about this, particularly in spectroscopy, where we have to examine everything minutely. The material we utilise most easily in the case of a mirror is silver; that is to say, we get a glass mirror, and silver it on the front surface. Now, the question is, does the silver reflect every ray in the same way that quartz would transmit it? Here I have a photograph which should give an answer to that question. The bottom half of the spectrum was taken as reflected from a quartz surface, the top half of the spectrum was reflected from a silver surface, and you will see that at one certain part of the latter the rays are very nearly absent, though beyond that again they are present. Where those rays are wanting is just at the end of the solar spectrum, and therefore, when using sunlight, it is no great advantage to use a quartz reflector over a silver reflector. In spectroscopy it is necessary to know exactly the qualities of all the substances with which you are dealing.

One question in photography and in spectroscopy is, what width of slit you would use—what slice of light would you allow to pass through? Here let me give you a demonstration. In the centre of this black disc there is a fine line of light, and there is a micrometer screw by which we can tell how many thousandths of an inch wide it is. As a rule, about $\frac{1}{600}$ of an inch is the dimension used for ordinary work.

I have been referring to the photographs to two spectra on the same plate, and I must show you how it is managed. For this purpose, it is necessary to have an adjunct to the slit, and that is a shutter, which is able to cut off half the slit at one time, and afterwards leave that part open and close the other half already used. By this means we can get one spectrum adjacent to another. In comparing spectra of different metals with each other, we are able to tell whether we have any two lines coincident one with the other.

Photographic spectroscopy is the easiest thing in the world when you know how to do it, but it requires a deal of patience to learn every dodge. As a rule, a photographer is a patient man; indeed, there ought to be no class of men who have more patience than photographers; hence spectroscopy should not be difficult to them.

Here is another piece of apparatus which is very useful in the spectroscope. It is an apparatus by which you can take a great many spectra on one plate. I need not enter into its details, it is simply a dark slide, which by a rack and pinion motion can be raised, so that the plate gives a fresh surface at each exposure. The only light accessible to the plate comes through an opening of about three-quarters of an inch wide cut longitudinally in the shade. By this method we can get about sixteen different spectra of different materials on the same plate.

Here is another piece of apparatus which is also useful in investigations with photography. It is, a slide in which you can expose plates in different gases or liquids, that is to say in water, in alcohol, in nitrogen, and so on. It is essentially a glass cell which slips into a dark slide especially adapted for it; on the top there is an air-tight junction which is screwed down, and there are two little tubes through which you can fill the cell with gas or water, or whatever other material you wish to use. This is very useful in investigating the behaviour of different sensitive salts under different conditions of moisture, pressure, &c. This cell has been used in a great many hundred experiments, and I hope it will be used in a great many more. Those who are going in for spectroscopy should not be without such an apparatus as this, for I do not believe much real investigation can be done without something of the kind. The sensitive salt of silver acts differently when isolated from its atmospheric surroundings, and the only way to ascertain how it does so is to expose it with other surroundings, and to differentiate the results one from another. There is no such thing as a perfect vacuum; you cannot say you expose a plate in vacuo, and, for this reason, I say you have to differentiate between the different media in which you expose a plate, in order to get at the true result which would happen supposing you could expose the plate in vacuo.

You saw last time how you could recombine a spectrum by means of a lens, to form white light.

Now, I want to show you that it is not impossible to develop a plate in white light. I expose a plate behind a negative to the electric light, and in the cell which is placed in the patch of white light is some developing solution (which is quite colourless). The plate is

dipped into it. The image comes out into it, although exposed to white light, without fog, which was supposed to be an impossibility. I have another plate placed behind the same negative. I expose half of that plate for half a minute to the white light on the screen, and the other half to apparent darkness, but in the same position on the screen, for a couple of minutes. The plate on development shows that the half which was exposed to what was presumably white light gives no image, while the half exposed in the dark shows a perfect picture. I dare say many of you have guessed my trick, for it is merely a trick, but for those who have not, I will show you how it is done. It is perfectly easy, by mixing two elements of light of different refrangibility, to produce a colour which, at all events, to our eyes is a white light. But you must not take it for granted that wherever you can see white light you can photograph with it, because it is quite possible you may not. It is only a trick, but some of these tricks bear fruit in a very practical manner. I will re-form white light again, and we will examine it by means of the colour-chart I showed you last time. You will see that when the red is placed in the white light there is blackness—no colour whatever—the yellow looks bright, as does the blue, all the other colours are gone except some few which are of a nondescript colour. The meaning of it is this, we have simply a combination of yellow and blue, which gives us the appearance of white light. [The blue and yellow rays were shown to be coming through two slits placed at the focusing screen of the camera.] The blue has no power of acting on the iodide or chloride of silver, neither has the yellow, and, therefore, the white light which is made by the combination of those two colours is powerless to act on films made of such materials as those. We can also produce a white light, practically, by a red and green, and if we examine this (which is a very good imitation of white light) in the same way, you will not see the whole series of colours in the colour chart any better than you did before. The red comes out perfectly, but the blue is no longer visible; the blue becomes green, and the violet becomes red; the yellow is also not intense. This is because we have only two colours present, viz., the red and the green. The apparent darkness to which we exposed the one-half of the plate was in reality the dark ultra-violet light, and I need say no more regarding that.

I told you last time that this was a very interesting way of studying the spectrum. You see how, by combining two lights together, you may have a light which is perfectly safe for certain salts of silver. On the screen is the spectrum taken on the three ordinary salts of silver—chloride, iodide, and bromide. The iodide stops exactly at the violet. Below that light we have no action whatever, and we, therefore, may expose an iodide plate with impunity to any rays below the violet. A bromide plate, you see, is sensitive down as far as the yellow, and, therefore, it would be impossible to develop a bromide plate in such a light as I showed you just now, whereas iodide is perfectly capable of being developed in such white light; the chloride again stopped very nearly with the limits of violet, so that it would be safe to develop a chloride plate in such a light.

[The lecturer concluded with a brief explanation of the diffraction spectrum.]

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

GROUP XXVIII.—PHILOSOPHICAL INSTRUMENTS.

By Prof. H. M'Leod, F.R.S.

The philosophical instruments in Group XXVIII., at the International Inventions Exhibition, are many of them of great interest. There are many novelties, and many examples of excellent workmanship. The first exhibits in the catalogue are those of the well-known manufacturers of microscopes and similar appliances, Messrs. Ross and Co., R. and J. Beck, and Crouch. These are all fine collections, and well worth careful examination. Messrs Ross show a new form of fine adjustment, in which the objective is moved by two differential screws turned by a milled head near the eye-piece. Messrs. Beck have a new cheap microscrope of the simplest construction, and a really practical instrument; they also exhibit an ingenious lamp, and several forms of microtome. Mr. Crouch shows a microscope with a new fine adjustment, which is attached to the stand, and moves the whole slide of the coarse adjustment; by this means, great steadiness is obtained, and there is also more room for the analysing prism in the tube above the objective; in this instrument the substage is attached to the stand by a hinge, so that it can be readily moved out of the way. He also exhibits a good portable microscope.

The other instrument makers, Messrs. Baker, Newton, and Co., Steward, and Thornthwaite, Horne,

and Wood, have large exhibits. Messrs. Newton and Co. show many magic lanterns, and a oxy-hydrogen microscope. Messrs. Steward several kinds of magic lanterns and dissolving-view apparatus, and many other instruments. Messrs. Thornthwaite, Horne, and Wood have devoted much attention to the perfection of limelight apparatus for the lantern; they also exhibit a reflecting equatorial telescope, with an improved method of clamping the hour circle. Mr. Baker's collection is too numerous to specify. Messrs. Adie, and Heath and Co. exhibit astronomical and surveying instruments; and Mr. Harling a modern theodolite (Whitelaw's patent), which is lighter than the ordinary instrument, and is specially adapted to the requirements of the mining surveyor, and for rough colonial work.

Mathematical and drawing instruments are exhibited by several well-known makers. Mr. Stanley has a large collection, proportionate to his deserved reputation. A new form of protractor, by means of which the angles between very short lines are easily and accurately measured, is worthy of note. Mr. Harling shows a new horizontal drawing compass which has many advantages over the old form of beam compasses, and also a bow compass, in which the point is pressed out by a spring, so that when small circles have to be drawn, the point is pressed into the holder until the pen or pencil rests firmly on the paper. He shows a very ingenious epicyclic elliptograph, by which a large number of symmetrical curves may be drawn. Mr. W. J. Wilson has sent his harmonograph for drawing curves, produced by the combination of two rectangular vibrations, the drawing pen being moved by cranks placed on two axes at right angles to one another, and connected by means of a series of toothed wheels. The angle between the two cranks can be varied, and the relative velocity of the two shafts can be altered by means of change wheels, and the throw of the cranks can be made to vary periodically, so that a considerable variety of figures can be produced, many of which are shown. A curve writer, but on a different principle, is exhibited by Mr. Groves.

Mr. Frost has a collection of the cheap transit instruments which have recently been introduced by Mr. Latimer Clark. They are intended for the use of amateurs for the determination of time by astronomical observation, and from a description of the instrument published by Mr. Clark, it appears that the results obtained by it are very accurate. Mr. Clark also prints annually a set of tables giving the mean time transit of the sun-stars for every day of the year, thus much facilitating the computation of the observations, the only correction necessary being that for the longitude of the station. In connection with the use of transit instruments, may be mentioned the ingenious slide rule of Mr. W. Heath for the conversion of sidereal into mean time; only one addition has to be made to the number found by the rule, and the result is accurate to three-hundredths of a second, which is sufficiently close for ordinary purposes, though it might not altogether meet the requirements of large astronomical observatories.

The slide rules, calculating machines, and recording apparatus at the Exhibition are of much interest. Mr. Stanley exhibits Professor Puller's cylindrical slide rule equivalent to a straight rule 83 feet long. The only criticism that can be made on this instrument is that as half the numbers are out of sight when looking at it, there is a little difficulty in hunting for the required figure, but with practice this difficulty vanishes; the results are necessarily accurate in consequence of the great length of the line of numbers. Mr. Dixon, who has devoted a considerable portion of a lifetime to the perfection of slide rules, shows a triple radius double slide rule, by means of which many complicated calculations may be rapidly made. There are many applications of such instruments in the arts and sciences, and their use cannot be too much commended. Mr. Dixon has also made some circular slide rules, consisting of a series of concentric circles, on which the figures are printed, and over which radial arms may be moved to act as indices; by this means great accuracy is attainable, as one such disc is equivalent to a straight rule of 50 feet in length. Messrs. Aston and Mander contribute the late Major-General Hannyngton's slide rule, in which the numbers are marked on a number of parallel strips of wood mounted on a frame, and which is divided in the same manner as Professor Everett's card slide rule described some years ago. Slide rules for special purposes are exhibited by Mr. Stanley for the use of engineers, some of which are beautifully constructed in card; it is a question, however, whether these special instruments are capable of very extended use, as they depend on the assumption that certain formulæ are infallibly correct, an assumption which would not meet with universal acceptance.

Under the head of calculating machines must be noticed Mr. Tate's improvements in construction of the arithmometer of Thomas de Colmar. In some of the earlier foreign machines the workmanship was rather faulty and unnecessarily complex, so that when the machine was much worn, it was difficult to repair. Mr. Tate has simplified the construction, and has employed the finest workmanship, although it may be doubted if the abolition of the locking expedients in the original machine, which he has partially replaced by friction, is altogether advisable. In Mr. Edmondson's circular machine, the locking arrangements of Thomas de Colmar are farther developed, so that every number disc is securely locked except when the mechanism requires them to move, whereas, in the original machine, the locking is effected only during part of revolution of the handle; at other times the fixity of the number discs depends on springs, which Mr. Tate has modified, and Mr. Edmondson has entirely eliminated. In the original machine there are two rows of holes through which the figures are seen, one row for products and dividends, and the other for multipliers

and quotients. Mr. Edmondson employs only one circle of holes, using different portions of the circle for the two sets of figures. He has also devised a means of enabling the operator to change at will the action of the disc which records the number of turns of the handle. In one position the recording disc shows an addition of one unit for each turn of the handle, in a second position of the slide a subtraction results, and in a third position the recording disc does not move. Thus the operator may at pleasure arrange the machine so that the multiplier may appear during the multiplication, or the multiplier may be first set and the handle turned until the figures disappear: this device much facilitates the use of the machine. In consequence of the circular form of the machine, any number disc may be brought opposite to any slide, which is of great use in long calculations.

An extremely ingenious calculating machine, invented by Mr. Hartmann, is exhibited by Messrs. Hedicke and Co. for the calculation of interest. By its means interest may be calculated for 1 up to 366 days, at rates from $\frac{1}{2}$ to 5 per cent. for every $\frac{1}{16}$ per cent., and from 5 to 10 per cent. for every $\frac{1}{8}$ per cent. The machine consists of two parallel rollers, and two slides working parallel to the rollers. The lower slide is adjusted to the per-centage, and the upper one to the number of days. The right hand roller is then turned until the capital appears opposite to marks on the lower slide, and if the exact amount is not found, the next lowest figure is taken, the additional amount being found by turning the left-hand roller until the excess appears under a stretched wire attached to the frame; the interest is found by adding the amount under the upper slide on the right-hand roller to the amount under the wire at the upper part of the left roller. The working of the machine is very rapid and accurate, and it is the first of the kind invented. Amongst calculating machines must be noticed the extremely beautiful tide-predicting apparatus made by Messrs. Légé and Co., and described by Mr. E. Roberts in the "Proceedings of the Royal Society" (xxix., p. 198, June 19, 1879). It is the same in principle as the instrument belonging to the British Association, and now in the South Kensington Museum; but it differs in some details, such as the employment of a fine wire in place of the long steel watch chain. It also includes a larger number of components, and a slightly different mode of moving the pulleys over which the wire passes is employed.

Messrs. Légé and Co. also exhibit a combined tide-gauge which records, in addition to the height of the tide, the variations of the barometer, and the direction and velocity of the wind. The barometer readings are recorded by means of a float on the mercury of the open limb of a syphon barometer. The velocity is recorded by a pencil moved by a wheel which makes one revolution for every fifty miles; and the apparatus for registering the wind direction is very ingenious, motion being given to one of two pencils by means of a cylinder with a screw thread cut on it. If the wind moves continuously in one direction, one pencil is raised and dropped at the end of a complete revolution; on the other hand, if the wind rotates in the other direction past the north point, the first pencil remains at rest, and the second is depressed and takes up the record. Mr. Baldwin Latham exhibits a portable tide-recording machine, driven by a lever clock with balance-wheel, so that the instrument may be readily erected in positions where a pendulum clock would be inadmissible. The float is suspended by a wire cord coiled on a drum, attached to a fusee and clock spring, so that a constant tension is maintained on the cord. By this device the usual counterpoise is dispensed with, and the axis of the drum working on the screw, the cord is maintained in the vertical position. A photograph is shown of a rain-gauge arranged on the same principle. Messrs. Yeates and Sons exhibit an electrical rain-gauge, and an electrical anemometer, and also an ingenious standard numerical pressure gauge, for testing steam and other pressure gauges. In this instance the gauge to be tested is attached to an iron pressure tube and a small hydraulic press; on working the press, mercury is forced up the pressure tubes, and makes contact successively with a number of platinum wires piaced at different heights in the tube; by means of a commutator, an electric current is passed through a bell-which rings on the mercury touching the platinum contact; thus more accurate measurements may be made than can be effected conveniently when a long glass tube is used. Dr. Rung, of the Danish Metereological Office, exhibits in the Foreign Court a self-recording rain-gauge, constructed on the principle of the sine balance, and also a fine self-recording barometer. In this instrument a syphon barometer is attached to the short arm of a lever working on knife edges, the barometer being counterpoised by a weight running on rollers along the long arm of the lever. This weight is moved along the balance by a nut travelling on a screw actuated by a train of clockwork. When the movement of the mercury in the syphon alters the position of the centre of gravity, a detent attached to the end of the long arm starts the train of clockwork in one direction or the other until balance is re-established. The nut carries an ink bottle which makes a trace on a sheet of paper kept in motion by a clock. Another set of recording instruments, of a different character from the previous, are Professor Ewing's seismometers. They are in the Japanese Court, and are exhibited by the Educational Department of Tokio. Japan is celebrated for its earthquakes, and much good work is being done by their investigation by Professors Ewing and Milne.

Another class of instruments includes the planimeters and integrators. It is much to be regretted that Professor Amsler-Laffon, of Schaffhausen (whose name appears in the first edition of the catalogue), has not sent his planimeters and integrators,

which have been, in many instances, the starting-point of other investigators. Luckhardt and Alten in the Foreign Court exhibit, together with many other excellent instruments, two new forms of planimeter which possess advantages over Amsler's original form. In the latter the rolling wheel was moved over the paper on which the figure whose area was to be measured was drawn, and irregularities of surface of the paper sometimes caused error. In the new machines the rolling wheel is moved by a surface of smooth cardboard, mounted on the instrument itself. This piece of cardboard is caused to rotate under the rolling disk by the movement of the instrument in one direction, the position of the disk on the cardboard being altered by the motion of the tracing point in a direction at right angles to the first. In the rolling planimeter, the instrument rests on a long grooved roller which allows it to move along the paper, and always parallel to itself; this roller, by means of a fine bevel wheel, causes the cardboard disk to rotate. The rolling disk which moves the counter is provided with a vernier, as in Amsler's instrument, and is mounted on an arm, the axis of which is a little beyond the edge of the rotating cardboard. To the axis is attached the long arm carrying the tracing point. In the precision planimeter, a heavy circular foot supports the frame of the instrument, and the wheel which turns the cardboard disk rolls on the edge of the foot; the arrangement of the indicating disk and tracing point is the same as in the previous instrument. The instruments are exquisitely made, and are very accurate.

Amongst the instruments exhibited by the Physical Society are the ingenious integrating machines of Mr. Vernon Boys, which have been described from time to time in the "Proceedings" of the Society. One of the most important is the steam-power indicator, which automatically records the work done on the piston of a steam-engine. In this machine there is a cylinder free to slide along its axis, but keyed on to the axis so that they turn together. Pressing against the cylinder is a small disc, the axis of which is supported by a fork, the fork turning on an axis at right angles to that of the cylinder and in the same plane. When the plane of the disc is parallel to the axis of the cylinder, and the latter is moved in the direction of its length, the disc alone is rotated; but if the fork supporting the disc is rotated through a small angle, and the cylinder moved longitudinally, the latter will be constrained to rotate, and its axis gives motion to a counting arrangement. In practice, the reciprocating motion of the cylinder is produced by the piston-rod of the engine, and the turning of the fork is effected by the steam pressure in the cylinder, turning in one direction when the pressure is above the piston, and in the opposite when the pressure is below. As a result, the cylinder turns continuously in the same direction, and the index records the horse-power expended. Besides this instrument, there are several others by Mr. Boys, in which rolling spheres are employed. The application of the sphere has been farther extended by Professor Hele Shaw, who has devised means for altering the position of the axis of rotation of the sphere without actually turning the sphere. This is managed by supporting the sphere between rolling discs, which are attached to a movable frame, so that very little work is expended in altering the effective position of the sphere. Professor Hele Shaw has adapted the use of the rolling sphere to many purposes, but the description would be hardly intelligible without diagrams. Mr. F. J. Smith has also made use of the rolling sphere in his ergometer for recording the work transmitted by machinery. Two pulleys are mounted on a common shaft, one rigidly attached and the other loose. The loose pulley, which communicates power to the machinery to be driven, has attached to it a bevel-wheel. The fixed pulley carries the axes of two bevel-wheels, the axes being at right angles to the main shaft. These wheels gear into the one on the loose pulley, and if they are prevented from rotating, the two pulleys are obviously rigidly attached, and will turn together. Round drums on the axes of the bevel-wheels of the driving pulley are two straps, attached to a crosshead sliding along the main shaft, and which crosshead is held back by a strong helical spring round the shaft, so that when the loose pulley is driven by the other, the spring is stretched, and is, therefore, a measure of the power transmitted. The main shaft is hollow, and through it passes a rod attached to the crosshead. To the other end of the rod a frame is attached, carrying between four rollers a sphere which rests on a disc turned by the main shaft, one of these rollers giving motion to an index. When no power is transmitted, the spring is unstretched, and the sphere is over the axis of the disc, and consequently the index does not move; when power is transmitted, the spring is stretched, and the sphere is pushed away from the centre of the disc, and a record of the amount of work is obtained.

A novel instrument, called a perspectograph, the invention of Mr. Hermann Ritter, is exhibited by Messrs. Hartmann and Braun, of Frankfort, and placed in the American Court. The instrument is extremely ingenious, but very complicated. By means of a series of rods and links, a tracing point is connected to a pencil, and with a particular setting of the instrument, when the tracing point is moved over a drawing in elevation, a perspective view is produced by the pencil. Conversely, a perspective view, or a photograph, may be made to produce an elevation; and by another arrangement, from a plan, some of the points necessary for drawing a perspective view can be obtained. It is much to be regretted that there is not someone always in attendance to exhibit an instrument of such interest.

The Kew Committee of the Royal Society exhibits some models of important instruments in use at the Observatory, such as the instrument for testing the accuracy of division of sextants and

theodolites, and Mr. Whipple's apparatus for testing the parallelism of the coloured glasses of sextants; also a model of the photographic apparatus for measuring the height of clouds. In the garden, the Royal Meteorological Society has a typical climatological station, comprising dry and wet bulb thermometers, maximum and minimum solar and terrestial radiation instruments, sunshine recorder and rain-gauge, and an earth thermometer.

Mr. Jordan exhibits his sunshine recorder, remarkable for its simplicity, as it consists simply of a cylindrical box with two apertures, in the inside of which a piece of sensitive photographic paper is placed. The sun, shining through the aperture, produces a trace on the paper within, and a record of duration of sunshine is thus produced.

In Mr. Hicks's case there is a large collection of meteorological and other instruments, amongst which may be mentioned his unalterable thermometers, which are made by heating the tubes after filling to a temperature from 50° to 150° Fahrenheit above that which they are required to indicate, for a period of sixteen days or more, when the final shrinking of the bulb is effected, the zeros rising sometimes as much as four degrees. Mr. Hicks also shows clinical and other thermometers, with a tube of a peculiar sectional form, by which the width of the mercury thread is magnified, and thus rendered more visible. He has also devised a new mode of applying white enamel to barometer tubes and measures, the glass being opaque except on two opposite sides: the divisions are thus more easily seen.

Mr. Stanley has two interesting meteorological instruments. One is a clock, the pendulum of which is a mercurial barometer; an increase of pressure raises the centre of oscillation of the pendulum, and causes the clock to gain. In the other, the clock pendulum is a mercurial air thermometer, and in this a rise of temperature causes an increased rate. By means of these instruments, the mean pressure and temperature over a long period may be more readily calculated than in the ordinary way.

The Cambridge Scientific Instrument Company exhibit some high-class instruments; not only is the workmanship excellent, but the designs, being made by gentlemen of high scientific attainments, leave nothing to be desired.

Sir David Salomons has a large case of instruments of his own design and manufacture, many of them showing much ingenuity and resource.

Sir Archibald Campbell exhibits a splendid spectrometer of his own design, the fine work being made by Mr. Hilger, and of the highest character. There is in the collection of the Physical Society a large spherometer of aluminum by the same maker.

Mr. Ward has made a very ingenious use of total internal reflection. By placing the end of a solid glass rod close to the flame of a paraffin lamp, a large amount of light passes along the rod; the rod may be bent in any required form without loss of light, and in this way the instrument may be used by surgeons for illuminating interior cavities of the body.

Messrs. De Grave and Co. have a fine collection of balances and weights for bullion, of measures of length and capacity, and other instruments. Mr. Oertling also shows many excellent chemical and assay balances.

One philosophical instrument remains to be noticed, although it is not placed in Group XXVIII., but amongst the mining appliances in the North Court of the South Gallery. It is the clinograph, or bore-hole test, of the late Mr. Macgregor, of Melbourne. In boring, it not unfrequently happens that the drill does not go down vertically, and it may be necessary to determine what direction it has taken. For this purpose the inventor passes down the bore glass tubes containing solution of gelatine. At the upper end of the tube is a bulb containing a small glass tube which floats vertically in the liquid; at the lower end of the tube is another bulb, containing a small magnet, also floating by means of a hollow glass bulb. The gelatine is heated so as to become quite liquid; the tubes are then lowered in a protecting brass case, and left in the bore-hole for some hours, until the gelatine solidifies. When the tubes are withdrawn they are placed in an instrument, and the inclination determined by the position of the upper float, and the azimuth by help of the position of the magnet. The tubes can be attached to the core extractor, and from the relative positions of the core, magnet, and float, the dip and strike of the strata can be determined.

The foregoing must be looked upon as merely an outline description of the exhibits in Class XXVIII. If space permitted, many other instruments might be described with advantage.

The number of visitors to the Exhibition for the week ending Tuesday, 4th inst., was 185,059. Total since the opening, 1,951,117.

CENSUS OF DENMARK.

Consul Ryder, of Copenhagen, in his report on the last census of Denmark, taken in December, 1880 but the returns of which have only recently been published, says that a considerable increase has taken place in the population during the last decennium, the actual figures being 1,980,257 in 1880, against 1,794,732 in 1870. Although this increase does not fully come up to that of the former decennial period, there are few other European States that show a higher rate of increase. The increase of population, which previously was larger in Jutland than in the islands, is now about equal for both these divisions of the kingdom; and as regards the islands, whereas the Island of Fyer previous to 1840 constantly showed the greatest increase, whilst the Islands of Zealand, Gotland, and Falster were remaining stationary, ever since that date there has been a steady tendency towards the reversing of such order among the islands,

and Zealand now occupies the first place in its increase of population. This advance on the part of Zealand is intimately connected with the very large increase which has taken place in recent years in its chief town, Copenhagen. The increase in the capital has been at a rapidly augmenting rate, namely, from 0·46 per cent. annually during the years 1701 to 1840, to 1·20 per cent. from 1840 to 1860, to 1·67 per cent. from 1860 to 1870, and, lastly, to 2·62 from 1870 to 1880. A similar movement is also to be observed in the provincial towns throughout the country, although not in the same proportion as is seen in the increase of the capital. In Denmark, as in most of the European States, there is to be observed the constant tendency of the population to migrate towards the towns at the cost of the rural districts. In comparing the returns of the last with those of previous periods, it is found that there has been a steady decline in the per-centage of increase of population throughout the rural districts, for while at the commencement of the present century there was a regular increase of 0·97 per cent., a gradual falling off took place in the following decennium, until it reached 0·92 in 1860-70, and is now reduced to 0·61 per cent. in the period comprised between 1870 and 1880. The result of this movement is plainly to be seen in the much smaller relative difference between the populations of the towns with those of the rural districts as in former times, for while the population in 1801 was nearly four times as large as that of the towns collectively throughout the kingdom, the relative positions in 1860 were only as 3·5 to 1, and in 1880 as 2·7 to 1. The change is most noticeable in Jutland, where the rural population in 1801 was nine times as large, whilst in 1880 it was only about five times greater than those of the towns. As regards the density of population, the neighbouring Scandinavian peninsula and Finland, with their large tracts of sparsely populated lands, have a population much less dense than Denmark, and the same is the case with Greece, Hungary, and Scotland; on the other hand, Saxony and Belgium maintained a density of population four times as great as that of Denmark; England and Wales three and a half times; the Netherlands two and a half; and Alsace, Lorraine, Baden, Wurtemburg, and Italy, twice. As regards the relative proportion existing between the two sexes, these are given in the returns of 1880 as 1,000 males to 1,036 females, and the number of members comprising a family is represented as 4·75, compared with 4·82 in 1870; 4·85 in 1860; and 5·03 in 1840; the decline being particularly marked in the suburban districts. Consul Ryder, in concluding his report, says that while the number of the population comprised in the professional and literary classes amounted to 131,978, and those engaged in industry and commerce do not exceed 590,000 persons, the agricultural interests are represented by a total of 930,612, thus conclusively showing the great importance of these interests for the Danish kingdom.

HOME INDUSTRIES IN ITALY.

The Italian Minister of Agriculture and Commerce, with a view of encouraging the manufacture of small articles, during the long hours of forced idleness in the winter season, by the population of the mountain districts, has issued a circular to the prefects and other local authorities, of which the following is an abstract:—"In many countries, especially in Germany, in Austria, and in Switzerland, the manufacture of little articles of wood for domestic use is carried on, on a large scale, and that industry, which not only forms a source of profit to the persons engaged and traders, also furnishes a livelihood during the winter to the poor inhabitants of the mountains."

The small forest industries are carried on to some extent in the different Alpine districts of Italy, but, from accounts furnished to the Minister, it appears that there remains much to be desired, both as regards the manner in which they are carried on, as well as on account of the imperfections in the tools used, and in the great waste of the raw material employed; besides, when compared with the articles made abroad, those of Italian make are found to be greatly deficient in design and good taste. Another reason which also contributes to the stagnation of that industry in Italy, is the relative high price of the raw material, and the low prices obtained for those articles, in consequence of the great competition made by metal goods.

In order to encourage the making of small articles by the inhabitants of the mountainous districts of Italy, the Minister urges the numerous agricultural committees, the various sections of the Italian Alpine Club, and all other institutions, as well as the different local authorities, to use their best endeavours to promote and extend the manufacture of these little wooden articles, giving, at the same time, the preference to those which find a ready sale in the neighbouring towns, are easily made, and are now imported from other countries in considerable quantities. There is no room for doubt that these articles might be made by the inhabitants of the Alps during the long days of enforced leisure, when, from the inclemency of the season, outdoor occupation is impossible, and, at the same time, would afford a profitable employment for winter evenings.

In order to bring this subject in a practical way before the peasantry of the mountain districts, the Minister is disposed to provide the necessary funds for the purpose of procuring and distributing samples of those articles which would be most saleable, and also for the purpose of providing tools by means of which the labour could be rendered more economical, and at the same time a better finish could be given to the articles manufactured.

In order to further the spread of the necessary technical knowledge of the various branches of this industry, the officials of the Forest Department will

be so instructed as to contribute effectually to this result; and the pupils of the Institution of Forestry of Vallambrosa will also receive special teaching on the subject. In the meanwhile, a professor of this institution, as well as some of the sub-inspectors of forests, have been charged with a mission to visit other countries, in order to collect all possible information on this industry, as well as samples and tools.

Correspondence.

CLIMATE IN ITS RELATION TO HEALTH.

In your report (July 24th, 1885) of Dr. Poore's admirable Cantor Lecture on "Climate in its Relation to Health," the lecturer refers to the outbreak of malarial fever in Mauritius in 1866. As I lived in Mauritius from 1861 to 1867, perhaps a brief account of my experience in this matter may be of some interest.

Although the island had been previously devastated by cholera, no epidemic malarial fever had visited it. On my reaching the island in May, 1861, I found myself, to my great regret, to be, without perhaps one exception, the only scientific man there. Some time in 1865 I made a tour of the island, collecting and subsequently analysing the various river, canal, and other waters.

I find that in my report given to the Royal Society of Mauritius, and dated December, 1865, there are these words:—"Above the railway diversion, the Pouce stream collects into a pond, which is, for the most part, stagnant. The analysis of this gave . . . . . . The great quantity of organic matter in this water needs no comment. The appreciable quantity of nitric and phosphoric acids, and the large quantity of alkalies, point unmistakeably to sewage as the main cause of the impurity. Whatever may be the merit of the question of the diversion of the Pouce stream in an engineering point of view, only one result can follow from the accumulation of an exposed mass of foul and stagnant water in one of the most densely peopled parts of the town.

"On both sides of the railway, as it leaves the town, is a series of pestiferous puddles. An analysis of one of these can only give a faint idea of their offensiveness to the sight and smell, and I presume, of their injuriousness to health. (Here follows the analysis). This water is evidently neither more nor less than sewage, which has in part found its way from the higher ground, in part been deposited in the immediate neighbourhood.

"If the sewage were poured into the sea systematically anywhere near the shore, it is not difficult to foresee that the stench arising would be intolerable, and the injury to health incalculable."

I do not believe that the outbreak of malarial fever was due to the "clearing of forests," or to the "upturning of virgin soil." It was due to the infatuation of those who did not know, and who even, when it was pointed out to them, could not see, that where lagoons of sewage and salt water are reeking beneath a semi-tropical sun, fever is the rule rather than the exception. And it was due to the fact that such lagoons were formed by the railway embankments. If my warning had been attended to, I believe that 500,000 people would be alive who are now dead.

I do not say that this would be of use to them or to others, but in a purely hygienic point of view it may be of some interest.

F. GUTHRIE.

26th July, 1885.

General Notes.

REMOVING MICROBES FROM WATER.—Professor Frankland has recently made a series of experiments on the relative efficiency of filtration, agitation with solid particles, and precipitation as a means of removing micro-organisms from water. His method was to determine the number of organisms present in a given volume of the water, before and after filtration. The filtering materials were greensand, silver sand, powdered glass, brickdust, coke, animal charcoal and spongy iron. These materials were all used in the same state of division, being made to pass through a sieve of forty meshes to the inch. Columns 6 inches in height were used. It was found that only greensand, coke, animal charcoal, and spongy iron wholly removed the micro-organisms from the water filtered through them, and that this power was lost in every case, after the filters had been in operation a month. With the exception of the animal charcoal, however, all these substances, even after being in operation for a month, continued to remove a very considerable proportion of the organisms present in the unfiltered water; and in this respect coke and spongy iron occupied the first place. Water containing micro-organisms was also agitated with various substances in the same state of division as above mentioned, and after subsidence of the suspended particles, the number of organisms remaining was determined. A gramme of substance was in general agitated with 50 c.c. of water for a period of about fifteen minutes. It was found that a great reduction in the number of organisms could be produced in this way; and the complete removal of all organisms by agitation with coke is especially to be remarked. Precipitation by "Clark's process" also showed that it affords a means of greatly reducing the number of these organisms in water. Dr. Frankland concludes from his experiments that although the production in large quantities of sterilised potable water is a matter of great difficulty, involving the continual renewal of filtering materials, there are numerous and simple methods of treatment which secure a large reduction in the number of organisms present in water.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

SOCIETY OF ARTS MEDALS.

The following Gold Medals have been awarded by the Council of the Society of Arts to Exhibitors at the International Inventions Exhibition, on the recommendation of the Juries:—

Group I.

*Sir Henry Bessemer, F.R.S.:—For the invention of Bessemer steel.

*Percy Gilchrist:—For the Thomas-Gilchrist basic process of steel making.

Group IV.

Hathorn, Davey & Co.:—For their domestic motor. (*Medal offered under the Howard Trust.*)

Samson Fox:—For the invention of corrugated iron flues for steam boilers. (*Medal offered under the Howard Trust.*)

Crossley Brothers:—For the "Otto" gas-engine. (*Medal offered under the Howard Trust.*)

Group XI.

Ralph Tweddell:—For his system of applying hydraulic power to the working of machine tools, and for the riveting and other machines which he has invented in connection with that system. (*Medal offered under the Howard Trust.*)

Group XIV.

*Badische Anilin und Soda Fabrik:—For their improvements in the manufacture of colouring matters and intermediate products from coal tar.

Group XXVIII.

William Crookes, F.R.S.:—For his improvements in apparatus for the production of high vacua, and for his invention of the radiometer. (*Medal offered under the Fothergill Trust.*)

* These medals were awarded by the Council in consequence of an application from the Jury Commission, who were anxious to carry into effect recommendations from the respective Juries, urging the claims of the Exhibitors to special recognition.

Proceedings of the Society.

CANTOR LECTURES.

CARVING AND FURNITURE.

By J. Hungerford Pollen.

Lecture I.—Delivered March 9, 1885.

In the remarks I propose to offer for your kind consideration, on a subject to which I have devoted a good deal of attention, I cannot pretend to put forward much that is new. What can be safely said on this or any other of the arts of design must be old matter, however freshly one may try to express it. I use the word safely, because critics on art are abundant, but not always precise or practical; and to speak in highflown and poetical language does not teach much.

I am quite aware that I shall address an audience as well informed on the subject as myself, and in many details of it much better. I shall have, nevertheless, now and then to start from the humblest beginnings, and to go over well-known ground. But I should do so to show from what original assumptions I start myself, so that we may travel as far as we can together, and may perceive when and where we fail to draw like conclusions, if so it be, from premises which we hold in common.

I begin, then, with the general consideration of a certain branch or development of the art of sculpture. I propose to treat it mainly as one of the sumptuary arts, concerned with the furniture of buildings and houses of everyday use.

French critics speak of wood-carving as sculpture in wood—correctly as regards the word. It is sculpture if we produce a figure, a flower, or a leaf out of solid wood or any other material. But the processes of what we call sculpture are different from that of carving with mallet and chisel, with which we are now concerned. I shall apply the word sculpture only to wood-work in very hard materials, in

which the surfaces have to be bored and scraped, and where the character of the design is suited rather to the gallery or the shelves of a collector, than to the decoration of walls or furniture.

Now, when any one not a wood-carver or furniture maker by profession ventures to assume the master's chair, a serious question is forced on his attention—at least on mine—and it is this. How comes it that any one should be lecturing on one of the arts connected with daily life, except a professor or a master to his own class? And it must be answered that wood-carving, as a sort of necessary accompaniment to the architecture of the day, seems to have fallen into desuetude. Sumptuous and well-made furniture is produced in London and other large cities; but carved cornices, carved panel mouldings, carved fire-places, doorways, and so on, are so very rare that we have to rouse attention to the carvers' art as if it were a revival. Nevertheless, the value in which carved work is held may be measured by the prices at which the fragments of Old London are being bought up, and the place which many of these fragments occupy in our national museums.

This disuse of carving in modern houses being our excuse, I hope we do not waste time in devoting an occasional evening to a subject in which I am myself so deeply interested.

Before going further, let us dismiss with a word or two what has been called sculpture in wood. Box is the wood most commonly used in wood sculpture; it is of slow growth, hard, close-grained, with narrower alternations of hard and soft in consequence, and less liability to shrink or split than is the case with oak or pine. It will retain sharp-edged lines of relief, incredibly fine, as we see in some modern wood-carving. It is in use for figure sculpture and other subjects requiring knowledge and skill of the highest kind. There is, however, a good deal of bold carving in box and pear, cut out in bold curves and sweeps, as if the wood were no harder than pine. The Kensington collections contain curious examples, the work of Italians of the 16th century. I should call all such work carving rather than sculpture, because of the character of the work.

2. I think it may be maintained, looking at Old London, that wood in our climate is the due complement of stone and brick. It is the inside lining of which the hard material is the outer coat. Wood panels are not freezing to the touch. They make interiors warm and comfortable, as well as rich and dignified. From the ease with which the materials can be cut, we get effectual decoration in actual relief of light and shade; and, once done, it is found to be as durable as the walls of the house, and in no danger of those dismal chips and peelings to which the plasterer's work is so subject.

I was struck with the contrast between the present system and the older one, by what I saw in a beautiful country house not long since. The house itself is old, the exterior finely carved in stone. The interior has been refitted and arranged at a great cost. The woodwork of shutters, and dados in two woods, is admirably fitted. All that the steam plane and modelling irons can do is finished to perfection. On the other hand, when I looked for carvings, I found lines of moulding, key-frets, and so forth, not carved in wood, but in lengths of stamped putty or other compositions glued on. In no long time I observed much of this applied composition curling up and coning off. The builder had to renew it. It struck me with astonishment that where so many thousand pounds were spent on joiners' work, one or two hundreds could not have been devoted to carving.

I do not know what convulsions of society or phase of manners has made so important a change, and eliminated from our houses decoration so necessary for their completion. It may be that the wars with which this century opened were a turning point in history with regard to the plastic arts. Perhaps when large London estates were rapidly covered with houses, that scourge of London arose—the modern speculative builder. Calculating on a rapid fortune, he invented one house. That one house has been repeated *ad infinitum* — a forlorn design it is, and the example so profitable to the builder has covered modern London with the dreariest streets to be seen anywhere in Europe.

It seems useless to discharge these thunders when the work is done, and so it would be were better prospects hopeless; but, in my opinion, this is far from being the case. The work of Mr. Norman Shaw and some other architects gives me some solid grounds of hope. They have grappled with a difficulty obvious to reflecting minds. All men are not agreed in their likes and dislikes, occupations or habits of life. Why should they all be compelled to live in houses of one and the same type and shape? The gentlemen I have named have tried to fit the house to the man or family that are

to live in it, not to force the inhabitants into houses that do not suit them. I do not profess to admire all I see in Queen Anne houses. I do not care for mere eccentricities, nor for details designed merely as quaintnesses, and put where they are without any corresponding convenience or advantage. But in general I think the inventors of our present red brick houses have done an essential service to London.

I refer to architecture because it is absolutely necessary to do so. Furniture, whatever we include in the term, is intimately connected with the house it furnishes. To treat of walls is to consider how the architect has built them, and how they ought to look inside when his house was finished. I do not reckon the house in the modern street—in Cubittopolis for instance, or the streets abutting on the New Road—I do not reckon them as worth the name of architecture. They are bricklayers' and carpenters' work, and nothing more. No mind whatever has left its stamp upon them. If carving finds its way into such houses it has been purchased by the occupier, who wants to make the one he lives in as unlike its neighbour's as possible.

Not so in the case of Old London; the narrow streets and lanes that were built after the fire contained houses of which many noble examples yet linger in the City. Consider, on the other hand. the vast and imposing public buildings that have risen between Palace-yard and Cromwell-road. It is worth while to ask what part such beautiful and effective decoration as wood-carving plays in the interior of those buildings, if we except the Parliament houses of Barry and Pugin? So far, then, as to the connection that there ought to be between architecture and carved wood; architecture in general, and that revived brick architecture in particular, of which I have had occasion to speak.

3. Now let us consider more particularly what the opportunities of the carver are, and what different methods of treatment he has at his command. I say *he*, but I ought to add *or she*, for we have many excellent lady carvers. What are the carvers' opportunities? There are the beams of which parts of all houses are constructed, and which. being of wood, are to be carved, *when the style of the architecture exposes them to view*, as in church and hall roofs, rooms in which the joints of the floor above are exposed, &c. As beams and timbers are concentrations of strength, they often have to bear walls that exceed their thickness, and project beyond their edges, such as door lintels, architraves, and the like. In these cases it is the angular edge, or so much of the edge as will not impair the strength of joists, or rafters, that can be carved effectively. In the case of a post, such as a stair newell, the king post of a Gothic roof, both edges and sides can be carved—extra length of wood being allowed for the purpose above the stair newells, or below the king posts—without interfering with the actual purpose of these posts, either in reality or apparently, apparent strength being necessary to due effectiveness.

As to running mouldings worked on edges, whether of beams, joists, rafters, or rails of any kind; or again, on the angles of door and window jambs and lintels, or on the framework of panels, the distinct rolls and hollows of which they consist must be limited in number. There should never be less than three, that a due proportion between the members may be maintained, nor should they be too numerous. Brackets have so many distinct ends projecting over the other. Cornices are made up of rows of brackets, or are one continuous running bracket. In this way, cornices represent thickness of wood projecting from the wall one above another, and should represent, say, an upper, a middle, and a lower projection. We ought to preserve this idea in complicated cornices, and give emphasis to the middle feature; then there will be a group of lines above it, and a group of lines below. These groups break the angle between roof and wall, or anything that represents roof, such as the top of a chimneypiece, of a doorway, and so forth. When you see an unmeaning succession of repeated mouldings, as you often do in builders' decoration, you will feel that the real idea of their relation to each other has never been grasped.

4. *Wall Surfaces.*—If from solid timbers we pass to wall surfaces, it is obvious that large wall spaces can be only covered by framed panelling. The framework must be of sufficient thickness to be grooved to take the panels, and this extra thickness has to be relieved from the heavy appearance of a mere thick edge. We have to ease down the edge by mouldings or lines in relief, some bolder, others finer, as the edges of the frame decrease till they meet the panel.

In a large room cut up into panelling, the general effect will depend on the size and proportions of the panels, to height and width of the room, and of the rows of panels to each other. Panelling requires to have some rows taller than others, and to have upper

and lower rows of less height than the general order. Upon the size of the panels will depend the boldness and size of the mouldings. We meet with large panelling in which the mouldings are planted into the junction of frame and panel, and exceed the thickness of both. I do not think it a good feature, and it is often a vulgarism. In carving mouldings there are two rules to observe—one, that the general form and outline of the original lines, or bars, or hollows moulded by the plane have to be preserved; another rule is that no work put upon these features ought to be allowed to quarrel with the direction of their lines. Foliage or plaited ornaments should run at right angles with that direction, and be delicate enough to lose themselves at a distance, at which the original moulding only can be distinguished. But in all large surfaces of panelling the greater quantity of moulding will be worked mechanically by a plane-iron filed to the curvature required. If you examine the small panelling of the 15th century, much of it will be found to have been executed by a tool worked by the fingers, *after the wood has been framed together*. The mouldings die down without meeting in the angles, but these mouldings are necessarily small and shallow. On furniture, chests, and other more important joinery, mouldings seem to have been been cut throughout with the carver's gouge.

Here, then, we have the treatment of edges of panels. How effective they can be made I need not say. Panels are sometimes made of wood, so thick as to be brought up to the level of the rails that frame them, and reduced by wide bevellings to meet the grooves of stiles and rails. The thick parts are left with a defined edge, as though a thin extra plank were added to the thickness. I consider that the proper purpose of this thickness is to allow of carving. Carving in these parts has to be in very low relief—historical subjects or leaf-work compositions. Figure-carving in such places is sometimes of extraordinary merit. Examples can be seen among the cabinets of the Soulages collection in the Kensington Museum.

There are, of course, parts or features of all interiors in which the carver has to put forth all his powers, those in which bold relief can be employed — door-heads, fire-places, and other prominent features. Here will come figure work, bold foliage, heraldry, and the like.

5. *Piercing and Turning.* — A different class of carved work consists in pierced carving; screens, fittings, of openings of various kinds in which light has to be seen through and not thrown on to wood-work. And again, another in the work of the turning lathe. No combined wood-work, on a large scale, can be carried on without the help of the lathe. We have but to look at old houses in our own country, and, indeed, may refer to the paintings and sculptures of antiquity in which furniture is represented, to see how large a part was played in its construction by the lathe.

In the 16th century, German turners showed astonishing ingenuity in the eccentric motions contrived in the turning lathe. But here I am only thinking of the commonest operations of that engine, and we can hardly appreciate how effective its action can be made. I will show, in a later lecture, some examples of Arab turned work.

In these various operations there is room for infinite variety of treatment, and judgment as to the best way of disposing one's powers with due economy of labour and cost. Employers have certainly to be encouraged to employ the carver; but to make his work effective it is indispensable that he should be able to show it in all varieties, whether abundant in quantity or not.

6. Generally and broadly speaking, what is it that makes carving effective? Not extreme skill in cutting, nor absolute imitations of nature, however good. It is a knowledge of, or rather, an habitual recognition of, laws that govern all composed design, which becomes what we know by the word *feeling*. We have spoken of mouldings on the edges of woodwork, and of compositions of foliage and figures, heraldry, and other ornamental composition. What is the law that governs the due prominence and arrangement of lines and masses? I consider mouldings as bars or borders of light, separated just so much from the surface to which they form an edge as to show their outline. This first edging is the largest and widest, as it is on the thick portion of the wood; on its shaded side it dies gradually till it ends in a smaller roll, and then, perhaps, a sharp arris. Here is a group of lines carefully adapted to each other. If we draw a doorway or an opening, an agreeable effect is produced by the mere use of a few lines of pencilling to indicate the gradual introduction from the light to the shadow. Mouldings produce a similar effect in woodwork. Mouldings may vary indefinitely in the proportions of the light and shadow

that run along them, and the way these elements are contrasted. If you watch the growth and decay of styles of architecture, it is in the multiplication, or breaking up, or loss of meaning of mouldings that these stages of decay and corruption are most obvious. Mouldings form three-fourths of the carver's work.

7. *Compositions in Full or very High Relief.*—Carry this principle further into the composition of carved groups, such as fill sunk panels or pediments. One may be able to carve the figure of a man, a lion, or a piece of foliage, but so to combine a number of such figures as to make each of them evident, to give the grace or the force that belongs to each of them respectively, and when combined, to form an agreable and well balanced composition of masses and line of light, here is the difficulty.

A picture is a little passage of history real or supposed, a piece of dramatic action—or it is a view of nature. Composition, a graceful arrangement of line, is of importance in either case. But to put together things that differ in nature and structure from each other, a man, an animal, a scroll of foliage, in the way required for the decoration of a pilaster, a pediment or a piece of wall, we have no such guide as the painter has for his picture. There is no story to tell, no connection as in the elements of a landscape. They must be brought up to the light, be combined or separated, or be partly concealed by scrolls or leaves in such ways as will look well even before the carver has entirely satisfied us what he intends his prominent masses to be, while still unfinished. The greater the dignity of the group, as, for instance, one composed of men only, as in a Greek pediment, the more distinct must be their shapes and the fewer decorative additions near them. The Greeks coloured their pediment compositions to make them more distinct than they could have been in mere white marble. As in mouldings there are larger and smaller lines, so in carvings in the round or in high relief, we have to compose the decoration in such ways as not only to give prominence to the most important portions, but generally to balance one side of it with its opposite, to have also a subordination of small to larger masses. Sometimes a balance is maintained by a repetition of detail on opposite sides of a central stem or figure. Sometimes in a more subtle manner, not by a repetition but by an equivalent, in different parts, perhaps, of the space to be filled.

8. *Relief.*—Regarding the amount of detachment or absolute relief that good carving in such cases ought to have, it will depend on the character of lightness and of movement the carver wishes to give his work. Generally, carving of this kind should never lose touch in in appearance from the mass to which it belongs, and should die gradually into the shadow. Much excellent carved work loses value from too much under-cutting, even in the work of so great an artist as Grinling Gibbons. Further, if carving is not to appear as if it floated in a disproportioned sea of shadow, neither should it be so crowded up as to become indistinct. I have seen sideboards in some of our great exhibitions in which much careful and laborious work was spoiled by ill-arranged crowding of figures and other details. Nor can decorative carving be carried, except to a limited degree, to the direct imitation of nature. As nature would not join animal and vegetable life together, so we are to represent natural life and living objects not as if we were making definite pictures of them, but such features of their nature as will gracefully express the arrangements of light and lines as are required for our immediate purpose, and no further.

The value of light and its concentration on masses of relief is of the first consequence to the carver, grace of line is second. Not that the two are separable, but the composition of masses seems to me the more difficult of the two.

9. I have alluded to pierced work; it is either made in scrolls of foliage or plaiting, such as we see in the furniture of the last century. Tables, chairs, rows of corner shelves, and so on. The legs and backs of chairs and tables are pierced, and the edges of tables and shelves, surrounded by tiny galleries of pierced mahogany. These objects require no great amount of knowledge to design, and scarcely deserve to be called carving, but they are not devoid of a certain elegance and agreeableness; generally, the material and workmanship are admirable. Oriental wood-carving presents us with frequent screens and large even spaces broken only by piercings, and the piercings less in extent than the solid portions. They are, if rightly placed, full of value in general arrangements of woodwork; broad even spaces expressive of repose, having the character of minute workmanship and richness, though mere repetitions of some simple pattern.

Here I leave off this short review of what seem to me the more important divisions of

the carver's field of work. I say little as to what he may attain to as a sculptor, or a carver of images, statuettes, and other fine examples of his skill. I want to confine your attention to subordinate and decorative work. A carver's first duty, no doubt, is to carve, to have a light and subtle hand, and a perfect command of the gouge and chisel. But the most dexterous of carvers runs the risk of faults which may spoil his efforts. He may be uncertain of his aim, not knowing clearly what he wants. He may be weak, wiry, and dry, or ostentatious and redundant; feeble, in short, or vulgar, or both. He ought to know what he wants, why he wants it, what the style of his walls requires for its due completion in each instance. If the work proposed is new to him, he has to master the spirit of it to the best of his abilities. He has to decide how to keep his carving light without loss of strength; full and sufficient, without crowding and redundancy; orderly and balanced with a judicious distribution of the work he can afford to bestow on his wall, or room, or house, or cabinet, or whatever he takes in hand; to secure unity of design throughout the whole, whatever variety of detail he may employ in its different parts.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The number of visitors to the Exhibition for the week ending Tuesday, 11th inst., was 124,146. Total since the opening, 2,075,263.

CITY AND GUILDS INSTITUTE.

From the Seventh Annual Report of Examinations in Technology, under the direction of the City and Guilds of London Institute for the Advancement of Technical Education, we notice that there is again a fair increase in the number of candidates who presented themselves, and a satisfactory proportional increase in the number of those who have passed. In 1884, 3,635 candidates were examined, of whom 1,829 passed. In 1885, 3,968 candidates were examined, of whom 2,168 have passed. Thus the increase of passes is six times more than the total increase in the number of candidates. There is a slight falling off in the number of subjects in which the examinations have been held, owing to the fact that in four of the subjects, viz., Salt Manufacture, Oils and Fats, Silk Manufacture, and Mechanical Preparation of Ores, the number of candidates was below the minimum for which an examination is held. Applications for examination were received, however, in 46 out of the 47 subjects included in the programme. From the returns furnished in November last, it appears that 6,396 persons were receiving instruction in the registered classes of the Institute, as compared with 5,874 in the previous year. These numbers do not include the students in attendance at the technical classes of various schools and colleges at which the Professors do not accept payment on results. Two new subjects were this year added to the list, viz.:—Boot and Shoe Manufacture and Framework Knitting, in which subjects 69 candidates and 40 candidates respectively presented themselves. Nearly all these candidates received instruction in the recently-opened Technical School at Leicester. The per-centage of failures on the results of the examination in all subjects has decreased from 49·7 in 1884, to 45·3 in 1885. The proportion of failures is still large, showing the necessity of better instruction on the part of the teachers, and of more careful and sustained work on the part of the students. Of the inability of the majority of the candidates to make intelligible sketches, the examiners continue to complain; but it is hoped that this defect in the education of artisans will gradually be remedied as linear drawing comes to be more generally taught in our public elementary schools. During the past session, 263 classes have been held in different parts of the kingdom in connection with the Institute's examinations. Of the 6,396 students in attendance at these classes, 3,271 presented themselves for examination, and that of these 1,670 succeeded in satisfying the examiners. Last year, the number of candidates who passed from the registered classes of the Institute was 1,387, showing an increase of 283, which is a large proportion of the total increase, viz., 333 of successful candidates. This year, for the first time, Manchester heads the list of provincial centres from which the largest number of candidates have passed, the number being 147 as against 115 last year. A like number of candidates have passed from the Polytechnic Institution, London. Next in order of merit comes Glasgow, with 119 as against 139 last year, Bradford with 97 as against 90, Leeds with 84 as against 70 (55 from the Yorkshire College), Bolton with 75 as against 98, and Huddersfield with 72 as against 39. It is expected that about 750 of this year's successful candidates will gain a full Technological Certificate, in virtue of their having obtained from the Science and Art Department the necessary qualifying certificates in science, in addition to their certificate in technology. Of the 1,829 candidates who passed last year, 566 obtained the full certificate. This increase of 184 in the number of full certificates is a very satisfactory feature in this year's examinations. Compared with the total number of successful candidates,

the per-centage of those to whom full certificates will be awarded has increased from 31·2 to 34·5. From year to year, improvements suggest themselves in the working of these examinations, by which they are rendered more practical, and at the same time better adapted to the requirements of the students. The opening of the Central Institution, by affording new facilities for the training of technical teachers, will, it is hoped, do much towards improving the character of the instruction in the Institute's classes in connection with these examinations. Summer courses for teachers, to be continued in subsequent years, have this year been held for the first time at the Central Institution, and the applications for admission to these courses show that the value of the instruction is likely to be fully appreciated by those for whom it is intended.—*Nature.*

THE MANUFACTURE OF JEWSHARPS IN VALSESIA.

The manufacture of jewsharps at one time was a very flourishing industry in Valsesia, and the numerous workshops in the valley produced a large number of these toys annually. At the present time it is carried on by a limited number of workmen only, notwithstanding that the demand is still considerable, and the hardware dealers are obliged to obtain the little instruments from Nuremberg, in order to supply their customers. This industry was originally introduced into the Valsesia from Boccorio, but the exact period is unknown; it is evident that the jewsharp, or, as it is locally called, "*ribebbe,*" was known as early as the 16th century, for in an authentic document dated 1524, it appears that a certain Andrea Gualcia of Otrosesia purchased from Giovanni Arienta, of Valla di Campertogno, a wood at a place called Ovaga di Curgo for *donzenas sexaginta de rebebbis.*

The village of Boccorio appears to have been the principal seat of this industry, and, during the last century, was so flourishing as to turn out, on the average, a box of jewsharps a day. A box contains 40 packets, and each packet 10 dozen, or 20 bundles (a bundle consisting of half a dozen). The average value of the box is 280 lire, or at the rate of 7 lire per packet; the retail price of a pair of these toys is 0·15 lire. A good workman can make 7 dozen per day, or about 4 packets weekly. The gross daily earnings would be, therefore, 4·65 lire, and deducting the expenses, which may be taken at about 1·15 lire per packet, there remains 3·85 lire as net profit per day.

It may appear strange that for the production of so simple an article as the jewsharp no fewer than twenty tools are used, including anvil, hammers, tongs, files, punches, &c., and requiring from twenty-four to twenty-five different operations, part of which take place at the forge, and part at the vice.

The jewsharp consists of two separate parts, the bow and the tongue, and the former is sub-divided into legs and circle, whilst the latter consists of the tongue proper and the hook. The retail trade in this article is in the hands of the small dealers in the district, whilst the wholesale is carried on at the town of Vasall, and boxes are exported *viâ* Genoa to Spain, Portugal, America, India, and other countries.

FRENCH VINTAGE OF 1884.

Her Majesty's Consul at Bordeaux says, in his report just issued, that it is officially stated that the aggregate yield of the last French vintage amounted to about 765,240,000 gallons, or 27,500,000 gallons less than in the previous year, but as much as 220,000,000 gallons less than the average production of the last ten years. It should, however, be added that in these ten years is comprised a year of exceptional abundance, viz., the year 1875. Comparing the results of last year with the production of 1883, it appears that the diminution of 27,500,000 gallons was due more especially to the reduction of the area of the French vineyards by the ravages of the phylloxera and other insects, and to the effects of more or less unfavourable weather. It appears that owing to the damage done by the phylloxera, a further diminution of no less than 113,000 acres took place last year in the aggregate area of wine-growing land in France, in spite of the many new plantations in several parts of the country, and of the more or less successful application of the best known remedies against the destruction of the vineyards by this and other parasites. Amongst the seventy-seven vine-growing departments of France, thirty-one added last year to the existing area of their vineyards, but on the other hand, forty-four departments, comprising the most valuable wine districts, experienced a further loss in the respective extent of their wine-growing land. With regard, more particularly, to the district of Bordeaux, in which are comprised the districts of Gironde, Charente, Vienne, Upper Vienne, Dordogne, Corrège, Lot-et-Garonne, Ariège, Gers, Upper Pyrenees, Lower Pyrenees, Landes, Lot and Upper Garonne, the total production amounted to 181,537,000 gallons, as compared with 164,683,000 gallons in 1883. In ten of the departments the production of 1884 was less, and in five greater than that of 1883, but it should be added that the vine grown in these latter five, viz., Vienne, Upper Vienne, Lot-et-Garonne, Gers, and Ariège, is, to a large extent, of a very inferior description. The most important of the departments of the Bordeaux district, and indeed of all France as regards wine production, is the Gironde, for it comprises not only the claret country *par excellence*, viz., Médoc and other districts where superior kinds of red wine are grown, but also the district of Sauternes, which produces the best known French white wines. The total quantity of wine produced in the Gironde during 1884 was 29,440,026 gallons, and compared with the

previous nine years, excepting 1881 and 1882, last year's yield was the least productive of the past decade. The primary cause of the considerable fall in last year's vintage was the unfavourable weather, but the continued ravages of the phylloxera and other parasites of the vines had also their share in reducing the production. Consul Ward says that the general opinion regarding the result of last year's vintage, as regards quality, was at first favourable for many Médoc wines, and the white wines of the district produced in 1884 were, and still are, universally acknowledged to be of exceptionally good quality. Since November, however, the majority of opinions at Bordeaux regarding the quality of the 1884 red wines appear to have become much modified, and though it is allowed by most experts that certain brands of Médoc will probably turn out well in the course of time, it seems, at the present date, to be the generally admitted opinion that a large number will be found to be a perfectly worthless liquid. The total quantity of wine exported from Bordeaux, during the year 1884, exceeded that of the previous year by about 2,732,000 gallons. This excess was largely due to larger shipments to South America, where the commonest kinds of Bordeaux wines are consumed in considerable quantities. To the United Kingdom there was a diminution in the exports to the extent of 151,750 gallons, compared with the year 1883, and it appears from an examination of the figures referring to previous years, that a gradual decrease in the exports to the United Kingdom has been taking place since the year 1880. As regards the importation of foreign wines into France, the abundant French vintage of 1883 caused a considerable falling off in the imports of Spanish, Italian, and other wines, which are used to some extent for making up the deficiency in the supply of the inferior descriptions of home grown wine. While some of these southern wines are used for mixing with the latter, a certain proportion of the same are re-exported from Bordeaux, particularly to South America, withont any further admixture under the name of "Bordeaux" wines. The total quantity of foreign wine imported into France, during the year 1884, amounted to 18,352,840 gallons, against 23,451,428 gallons in the preceding year, or a decrease of about 5,100,000 gallons.

NOTES ON CANALS.

The following is a summary of three papers submitted to the International Congress on Inland Navigation, held at Brussels from 24th May to 2nd June, 1885 (see *ante* pp. 908-910), and copies of which will be found in the library :—

Relative Level of Canals.

by A. Huet.

As a rule, canals are cut so as to be entirely below the surface of the soil. In Holland, however, they are often cut so that only part of their section lies below the original surface, the upper portion of the banks being formed by the earth excavated. This method has the advantage of reducing the earthwork by more than half, and also the width of ground required, thus considerably diminishing the cost of construction in many cases; but, on the other hand, it has the disadvantage of giving a higher level to the reaches of the canal, and of increasing the rise and fall of one of the locks, generally that at the end of the lower reach.

Feeding Canals.

by A. Huet.

The loss of water in the upper reaches of Canada, due to evaporation, infiltration, leakage through lock doors, and the passage of boats through the locks, may, where there do not exist sufficient means of natural water supply, be compensated by an artificial supply. Canals may be cut and worked under conditions naturally disadvantageous, if pumps be employed, above each lock, for raising to the upper reach the quantity of water used and lost, as the lowest reach generally affords a sufficient supply for the whole. The pumps required will, in any case, be of smaller dimensions than those used for draining the Dutch polders.

The Future of Canals.

by J. Vandrunen.

In answer to the question, "Should new canals be made, and those already existing be improved; or should the latter be filled up, and their place be occupied by railways?" it may confidently be replied that, notwithstanding the great disadvantages under which canals now labour, they carry as much as railways, when both serve the same localities; and their vitality, in spite of neglect, proves their utility.

The tendency of railway working is towards increasing speed; and this renders more and more difficult for both the intercalation of slow goods trains between fast passenger trains. Increased speed means increased cost; but a high speed is of no advantage to a large proportion of raw material, which often has to pay for transport four or five times before it is worked up into the finished product.

For an equal quantity of matter carried, the canal requires far less capital than the railway as regards making, maintenance, and working. A considerable portion of the expense incurred in making a canal is often repaid by the increased value given to marshy land, which it drains, and where a railway could only be made with difficulty. One horse will draw on a canal the weight of a whole train load on the railway.

The transport arrangements of a country should include both railways and canals, which, to the great benefit of commerce and industry, would share the traffic, each according to its aptitude. The canal would not take from the railway either passengers or small quantities of goods requiring speedy delivery, but would carry substances sent in large quantities, and on which the profit is small. Thus the canal

would free the railway from a clog upon its action, and enable it the better to organise a rapid passenger service, to its own profit and the public benefit.

The great advantage of canals is the cheap transport they afford; and this contributes a universally advocated remedy for the present stagnation of trade. Capital must be directed towards an increase of commercial activity; and everywhere manufacturers and Chambers of Commerce demand lower rates of transport. The large centres of Europe, especially the capitals, are now endeavouring to bring maritime communications to their very doors, and that by means of canals where natural water-ways are wanting. Only ship canals permit the capital of a country to aid commercial operations, because capital is not so easily displaced for commerce as it is for industry. Large towns and cities possessing the necessary capital have a universally acknowledged interest in becoming themselves the centre of business. In this way costly intermediaries are suppressed, transhipment is avoided or minimised, and the chances of theft and damage are reduced.

The commercial and industrial prosperity of a country now depends on the organisation of its system of communications, and every country should possess a system of canals of moderate section, and a few ship canals laid out judiciously, that is to say, a map on which the quantities and direction of the transports are shown graphically, points out where the making of a ship canal is indicated, whilst taking into account the physical features.

GOLD PRODUCTION IN RUSSIA.

A report has recently been made by the United States Consul at St. Petersburgh on the gold production of Russia, and it is stated there that, from 1820 to 1850, Russia ranked first among gold-producing countries, yielding, at the time of the discovery of the mines of America and Australia, 12·7 per cent.; from 1861 to 1870, 14 per cent.; and at the present time about one-fifth of the world's production. Consul Stanton says that, as elsewhere, gold is obtained in Russia either by quartz crushing or placer washing, the yield of the latter system far exceeding that of the former. In Russia, the gold-bearing districts are—The Ural district, Western and Eastern Siberia, and parts of Northern European Russia and the Caucasus. The production of gold in the Ural district began in 1745, when gold-bearing quartz was found on the Pishma, a branch of the Tobol, north-east of Ekaterinenburg. Up to 1810, the yield of these mines steadily increased, reaching in that year its maximum, 9,540 ounces of fine gold, gradually decreasing until, in 1838, it amounted to but 1,008 ounces. The first placers were discovered about the year 1774, and from that time more attention has been paid to gold washing than to quartz mining. From 1822, the yield of the placers exceeded that of the mines, and has constantly increased. The total gold production of the Ural district, which is worked by the Government, and also to a certain extent by private enterprise, amounted during the period 1814 to 1880, to 9,022,260 ounces. In Siberia the regular mining of precious metals began in 1704, and the first metal found was silver, which was discovered at Nertshinsk, and in 1829 the first gold placers were discovered. Siberia is divided into two great districts, Western and Eastern Siberia, and the mining districts of the former are the Altai Mountains, the Maryinsk district, the Akmolinsk, and the Sempalatinsk regions. The two first are of the greatest importance, and have respectively produced, up to 1880, the former 1,055,544 ounces, and the second 969,624 ounces. The total amount of gold found in Western Siberia from 1829 to 1880 is 2,064,240 ounces, and almost the whole amount is the production of washings. In the districts of Eastern Siberia the mines are far richer than those of Western Siberia. They are situated in the Atshinsk, Minushinsk, Krasnoyarsk, Yenissei, Kansk, Nijni-Udinsk, Irkutsk, Wercho-Lensk, Werchnie-Udinsk, Bargusinsk, Nertshinsk, Priamursk, Olekminsk, and Amoor districts, and also along the coast of Eastern Siberia. The two first mentioned mines yielded from 1834 to 1880, 1,059,048 ounces of gold. The Krasnoyarsk mines are wholly unimportant, while those of the Yenissei district belonged to the richest of Eastern Siberia, and produced from 1841 to 1880, 10,468,380 ounces. The gold fields of the Kansk and Nijni-Udinsk districts are also among the richest ones, and produced from 1841 to 1880, 760,152 ounces. The mines of the Irkutsk district are unimportant and worked irregularly, as are also those of the Wercho-Lensk, and Wercknie-Udinsk district. The Bargusinsk is one of the wealthier regions, and has yielded, from 1856 to 1880, 536,064 ounces. The Nertshinsk mines belong to the richest of Siberia, and yielded, from 1836 to 1880, 2,731,428 ounces. The Preamursk district is unimportant, whilst the mines of the Olekminsk territory have been among the most productive in Siberia. They yielded, from 1851 to 1880, 4,994,472 ounces of gold. The mines of the Amoor district consist of four groups, whose united production, from 1868 to 1880, was 901,740 ounces of gold. From the earliest discovery of gold in Eastern Siberia, down to the year 1880, the total quantity produced in that district amounted to 21,582,720 ounces, and almost the whole of this amount is gained by washing. The gold mines of Finland are situated in a portion of Finnish Lapland, in the government of Meaborg, where both soil and climate form serious obstacles to mining, and the yield is altogether unimportant. The mines of the government of Archangel, situated in the district of Kemsk, are of little importance, while the mines of the Caucasus are scarcely of any value. Consul Stanton gives a table showing the total production of all the gold-bearing districts in Russia for various periods, commencing

with the year 1814, and says that from that year down to 1880, the latest year for which any statistics are available, the total production amounted to 32,718,000 ounces, of which the Ural district was represented to the extent of 27·6 per cent.; Western Siberia, 6·4; Eastern Siberia, 66·0; and Finland, ·01. Consul Stanton, in conclusion, says that the centre of gold production in Russia has now reached the Yakutsk district, and as the natural boundaries of Siberia must soon be reached, should the easterly progressive movement continue, and as the various goldfields from the Ural mountains eastward are being rapidly exhausted, and no new fields of any importance have been recently discovered, it may be assumed that Russia, as a gold-producing country, has already attained her maximum production.

SANITATION.

The Housing of the Working Classes (England) Bill, introduced into the House of Lords by the Marquis of Salisbury, passed the third reading in the Commons on Wednesday, 12th inst., and the Public Health (Metropolis) Bill, also introduced in the House of Lords, was issued in printed form on Saturday last. The latter Bill, which is essentially a consolidation Bill, with some new suggested provisions which will have to be discussed, is, no less than the former, an outcome of the recent Royal Commission on the Housing of the Working Classes.

The practical cleansing of all public gutters, drains, and grating openings to sewers, with frequent application of disinfectants, is now more than ever attended to in the metropolis. The condition of courts and lanes leading off our main thoroughfares show the greater attention paid to the cleaning of yards, the removal of "dust," which to the "dustman" means rubbish of all kinds. An indication that an interest in sanitary knowledge is increasing throughout the country may be seen in the results of the examinations of the Science and Art Department. The subjects grouped under the head "Hygiene" have, it appears, attracted this year more candidates than last, which was the first year of the institution of the subject. In 1884, the numbers were 2,194 candidates, of which 414 passed first class, 1,401 second class, and 379 failed. This year there were 2,621 candidates, of which 575 passed first class, 1,635 second class, and 411 failed. The subject, too, is one on which teachers from the country attend Professor Corfield's lectures at the Normal School of Science, at South Kensington. The amount of unofficially recognised work in sanitary teaching which is going on all over the country, it is difficult to estimate, but it is known to be great.

In the Housing of the Working Classes (England) Bill, provision is made for the manner of adoption of some of the clauses of the Labouring Classes' Lodging-house Act of 1851, and the Labouring Classes' Dwelling-house Acts of 1866 and 1867; the "Artisans' and Labourers' Dwellings Act, 1868;" the "Artisans' and Labourers' Dwellings Improvement Act, 1875;" and the "Artisans' Dwellings' Act, 1882." Many of the clauses in these Acts are, by this Act, repealed. "A tent, van, shed, or similar structure, used for human habitation," is to be under inspection control, and a sanitary authority may make bye-laws for promoting cleanliness in them, and preventing overcrowding. Accommodation for hop and fruit pickers is also to be under control.

Under the Public Health (Metropolis) Bill, special attention is given to a "proper supply" of water for lodgers, and to the inspection of "common lodging-houses" and their registration. The definition of what constitutes a nuisance is taken partly from previous Acts, and includes overcrowding, and any chimney (not being the chimney of a private dwelling-house) sending forth black smoke so as to be injurious.

In cases where smoke is not consumed, no nuisance shall be held to be caused if the Court before whom a person is summoned is satisfied that the fire-place or furnace is constructed in such a manner as to "consume as far as practicable," and that it is carefully attended to by the person in charge. A clause referring to cellar dwellings requires that there shall be an area four feet wide along the entire frontage, and that two feet of its height shall be above the level of the footway of the street.

CHARCOAL BURNING IN ITALY.

Amongst the processes used in the various industries relating to forestry that of charcoal burning is one of the most primitive, and it has been carried on from time immemorial in Italy, without any attempt, it would appear, to introduce into it improvements of any kind. According to recent reports made to the Minister of Agriculture, the yield of charcoal does not exceed on the average 15 per cent. of the weight of wood employed, and it is shown that were some process of dry distillation used, the yield might be doubled.

The *Agricoltore Piceno*, in a recent number, describes a simple process of charcoal making, the apparatus or plant required not being beyond the means or intelligence of the ordinary charcoal burner. It consists in heating, in large iron or fire-clay cylinders, the wood to be "cooled." These cylinders must be closed hermetically and fitted with a pipe, communicating with a simple condensing apparatus. Besides gas, liquid products such as crude acetic acid, tar, &c., are obtained, and a yield of charcoal equal to 30 per cent. of the weight of wood used remains in the retorts. If the distillation is carried on at a high temperature, the charcoal is black and dense, whilst a lighter quality, and of a reddish colour, is obtained at a low one. The work-

ing expenses are relatively small, as when once the fire under the retort is lighted, the gases given off from wood can be utilised for heating purposes, whilst the sale of tar and other products fully compensates for labour, wear and tear of plant, &c. The charcoal obtained by this process is far superior to that made in the ordinary way, and not only is preferable for domestic purposes, but also for the manufacture of gunpowder, &c.

Notes on Books.

Spectrum Analysis. By Dr. H. Schellen; translated by Jane and Caroline Lassell. Edited by Capt. W. de W. Abney, R.E., F.R.S. Second Edition. London: Longmans, 1885.

In 1872, the Misses Lassell published a translation of Dr. Schellen's work on "Spectrum Analysis," founded on a course of lectures delivered in Cologne, in 1869. This edition was edited by Dr. Huggins, who contributed a number of notes, besides revising the text. Since 1872 the science of spectroscopy has made very great advances, advances which have rendered obsolete a great deal of Dr. Schellen's original work. Feeling this, the author had himself intended to reconstruct his work, but illness, terminating in death, compelled him to transfer to other hands the completion of his design. It appears that the new material collected by Dr. Schellen has been utilised for the present edition, which has been considerably modified by the editor, Captain Abney. Large portions of obsolete or unnecessary matter have been cut away, and corresponding additions have been made. Amongst the new additions may be noted a chapter by the editor on the infra-red region, while the portion dealing with spectrum photography has been greatly amplified, if it is not all additional. The absence of an index from the earlier edition, a fault now rectified, renders accurate comparison a little difficult. Much of the original matter relating to eclipses of the sun, and the spectroscopic observation of them, has been omitted, and its place taken by newer information, while throughout the book many new details are given, and the information generally brought down to date. For instance, a full description of Professor Langley's bolometer is given; and one of Mr. Common's wonderful photographs of the nebula of Orion, taken quite recently, has displaced, as frontispiece, the table of spectra originally given. An account also of Dr. Huggins's latest work on "Spectra of Stars" has been introduced.

Like its predecessor, this edition is fully illustrated, many new engravings being introduced, and some of those of the earlier edition omitted.

The Fallacy of the Present Theory of Sound. By Henry A. Mott, jun., Ph.D., New York. London: Trübner and Co. 1885.

This is the substance of a lecture delivered before the New York Academy of Sciences in December, 1884, in which an attempt is made to prove that the wave theory of sound is a fallacy.

Familiar Trees. By G. S. Boulger. London: Cassell and Co.

Messrs. Cassell have just published the first part of a work under this title, which is intended to give a popular account of the principal English trees. This part, which contains two coloured illustrations, deals with the oak. It is to be continued monthly.

Census of 1881. Instructions to the Clerks employed in classifying the Occupation and Ages of the People. Printed for official use only.

In the Census Reports for 1881, the population of England and Wales was classified under some 400 separate headings, these headings being themselves grouped into sub-orders, orders, and ultimately into six large classes, namely, professional, domestic, commercial, industrial, and unoccupied. As there were only 400 headings in the classification, and the occupations under which persons return themselves are not far short of 12,000, it was necessary to construct a dictionary of occupations, with instructions to the clerks engaged in the abstraction as to the heading to which each several one of the 12,000 occupations should be referred; otherwise, when the clerk came on such mysterious callings as bull-dog burner, doctor maker, bullet-pitcher, hoveller, and the like, he would not know how to deal with them. The book of instructions has not been published, but a copy has been presented to the Society. It contains a record of the technical names of the multitudinous callings which are to be found in this industrial country. Moreover, in addition to the alphabetical index of these callings, the ultimate callings are also grouped in a separate part of the instructions under the several headings to which they belong, and, whenever the necessary information could be obtained, they are so grouped as to show the organisation of the industry; for instance, the numerous technical names that distinguish the workers in a flax mill are grouped in the order of the successive processes through which the material passes. Much labour has evidently been expended in gathering together from all sources the information required for the compilation of this "Book of Instructions;" but as it can hardly be expected to be complete, Dr. Ogle, the statistical superintendent in the General Register Office, has appended a notice to the volume,

requesting any person who may detect errors or omissions to be good enough to send notice of the same to him at Somerset-house.

Obituary.

Mr. Robert F. Fairlie, whose death took place suddenly on the 31st of July last, was a member of the Society of Arts from 1865 to 1883. The system of narrow gauge railways devised and worked out by Mr. Fairlie has been use in may parts of the world, and his principal invention was the double bogey engine, a model of which is now in the Inventions Exhibition, and received the award of a silver medal from the juries. Mr. Fairlie had recently reason to hope that his system was coming into more extensive use than it has yet attained; but the fever which he caught while surveying for a line proposed to be laid in Venezuela incapacitated him for some months before its fatal termination. In 1868, Mr. Fairlie read a paper before the Society of Arts on "Railways and their Management."

General Notes.

Electric Lighting in Italy.—Another Alpine town will shortly be lighted by electricity, and following the example of Aosta, the municipality of Vazallo have recently decided to illuminate the town by electricity. The system to be adopted will be that of Cruto, and the streets will be lighted with 70 incandescent lamps. The current will be furnished by two dynamos driven by a turbine, as abundant water power is at hand in the torrent Sesia. Besides the public lamps, the dynamos will supply from 90 to 100 lamps in private houses.

Patents in Belgium and Austro-Hungary.—From the time the law of 1854 came into force to the end of 1883, no less than 29,213 patents of invention, 26,247 of importation, and 8,674 of perfectionment or improvement, making 64,134 altogether, were granted in Belgium. During the same period 45,525 patents, not including those of improvement, were abandoned or annulled, the following figures corresponding to the years, beginning with the second—20,457, 11,599, 5,755, 2,695, 1,571, 988, 665, 412, 292, 256, 157, 118, 90, 109, 85, 27, 12, 14. 23, that is to say, more than 45 per cent. of the patents were abandoned after the first year. In Austro-Hungary, from 1852 to 1884, there were 34,569 patents, of which 10,479 were granted from 1852 to 1869. Of the latter only 98, or scarcely 1 per cent., were kept up for 15 years; while, out of the 24,090 granted between 1870 and 1884, only 6,422 still remain in force, this number being chiefly made up of the patents lately granted.

Bessemer Steel in the United States.—It appears from recent returns that the total production of Bessemer steel ingots in 1884 was 1,538,355 tons, as against 1,654,627 tons in 1883 and 1,696,450 tons in 1882. Of the first-named amount Pennsylvania produced 1,029,244 tons, Illinois 339,068 tons, and the remainder was distributed between New York, Ohio, West Virginia, Massachusetts, and Colorado. The *Bulletin* published by the American Iron and Steel Association reports that there were twenty-one Bessemer plants completed, and one building, in the United States in 1884. Missouri made no Bessemer steel last year, but West Virginia and Massachusetts are new producing States, which made their first steel of this kind in 1884. In 1882, the quantity of Bessemer steel rails produced in the United States was 1,438,155 tons; in 1883 it was 1,286,554 tons; and in 1884 only 1,116,041 tons. As compared with 1883 there was thus a reduction of 13 per cent., and as compared with 1882 (when the maximum steel rail production was reached) there was a reduction of 22 per cent. The iron rails produced in 1884 amounted to 21,891 tons, which was but a little over one-third of the production of 1883. The open-hearth steel rails produced in 1884 amounted to 3,000 tons, which was not one-third of the amount produced in 1883.

The Eucalyptus in Italy.—According to a writer in the *Gartenzeitung* of Berlin, the plantations of the Eucalyptus in Italy have been far from realising the results that were anticipated from them, as a means of preventing malarious fever, and neither the soil or climate of that country appears to be favourable for the growth of this tree, and he recommends the *Quercus rex*, the *Laurus glandulosa*, and certain varieties of the maple as being far better suited for the purpose. Another authority, Dr. Dieck, recommends the *Acer californiensis*, a tree of very nearly as rapid a gravity as the Eucalyptus, the *Acer macrophilium*, of California, the *Acer insignis*, of the Himalayas, all of which are well suited for cultivation in malarious districts in Italy; the *Salyx babylonica*, *Populus angulata*, *Hyterophylla*, &c., are all said to be preferable to the Eucalyptus and more suitable to the climate, and contain similar properties to those of the Eucalyptus, to which it owes its efficiency as a preventative against the malaria. Dr. Dieck, however, considers that the root of the evil lays in the indiscriminate cutting down of the trees on the mountains, and that their re-wooding would do far more towards checking malaria, than any measures taken in the marshes, which districts have been reduced to their present state by forestal mismanagement and neglect.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

"OWEN JONES" PRIZES, 1885.

This competition was instituted in 1878, by the Council of the Society of Arts, as trustees of the sum of £400, presented to them by the Owen Jones Memorial Committee, being the balance of subscriptions to that fund, upon trust to expend the interest thereon in prizes to "Students of the School of Art who, in annual competition, produce the best design for Household Furniture, Carpets, Wall-papers, and Hangings, Damask, Chintzes, &c., regulated by the principles laid down by Owen Jones." The prizes are awarded on the results of the annual competition of the Science and Art Department.

Six prizes were offered for competition in the present year, each prize consisting of a bound copy of Owen Jones's "Principles of Design," and a Bronze Medal.

The following is a list of the successful candidates :—

1. Lillie M. Betts, School of Art, South Kensington. S.W.—Designs for floor-cloth.
2. Henry Cadness, School of Art, Manchester.—Designs for stained glass window.
3. Dora Harrison, School of Art, Manchester.—Designs for calico.
4. Maud Johnson, West London School of Art, 155, Great Titchfield-street, W. — Designs for Cretonne.
5. Francis G. Moore, School of Art, Manchester.—Design for wrought-iron gates.
6. Edgar H. Turner, West London School of Art, 155, Great Titchfield-street, W.—Design for the decoration of a frieze.

Proceedings of the Society.

CANTOR LECTURES.

CARVING AND FURNITURE.

By J. Hungerford Pollen.

Lecture II.—Delivered March 16, 1885.

In my last lecture I ventured to make a few observations on the state of our present London and country houses ; how small an amount of care or thought seemed to be bestowed on wood-carving in them. It seems to me a sort of necessity to employ this kind of decoration inside our houses ; and that wood panelling and carved wooden door jambs, seats, bookcases, cabinets, and so forth, are not to be dispensed with if we are to make them decorative ; and to be decorative in some form or other is an acknowledged necessity ; even to the speculative and "jerry builder," as we see in his grotesque and vulgar cement work. Moreover, this neglect of carving is of modern growth, and we pay a tribute to our taste for the art of carving in the prices we are paying for the merest fragments of Old London. From this I went on to the consideration of those features in ordinary woodwork which are decorated by the gouge and chisel—and to reasons for this decoration. I also insisted on the pleasure which we derive from the use made of light in carving, light found and regulated by that artificial shadow or darkness created by the carver. It is the varying play of light over his masses of carving, his mouldings—large here, small there—his sharp lines of shading and other methods by which he softens off the transition from one surface of his woodwork to another ; by which he rids himself of raw, poor and starved edges, or harsh angles. He makes his surfaces and his hollows die into each other, and the gradations of these interchanges vary with the increase or decrease of the light in his rooms, or outside his doorways and window openings.

To-night we are to discuss a remarkable epoch in the history of modern art, and, of course, of our own special subject. This epoch goes under the general name of the Renaissance, or *cinque cento*,—"the 16th century." Renaissance, or revival, signifies that from the time of this change the arts, as they have come down to us, went through a regular new birth ;

that the arts of design had died out, and that a fresh birth took place, which has resulted in a life altogether new. What was the history of their renewed life, and whence was it derived?

Well, the old architecture, sculpture, painting, enamelling, jewellery, and the arts of design in every form, in the early centuries of our era, grew up under the protection of the Roman power. That great empire, the strongest and the widest which the world has seen, embraced all central Europe, and all the countries that border the Mediterranean Sea. The Greeks, who had been the most gifted artists in the world, had become Roman subjects; their temples at Athens and Olympia were standing untouched and perfect; with their statues of bronze and marble, and ivory and gold. Delphi, with three thousand statues; and treasuries in the shrines and temples of other famous places were crammed with busts, little statuettes, medallions, heads cut in precious materials, sculptured crystals and gems, costly jewels of rare workmanship, every sort of precious offering. Corinth was a city of refinement and pleasure; Athens the university of the world. All these splendours the Roman emperors and patricians imitated: and much they imported into Rome. Excellent Greek artists and workmen were attracted by the high wages to be had in the capital. Countless copies were made of the old masters, masterpieces of Pheidias, Praxiteles, and others, whose original works were still in perfect condition. These copies represented the old art which passes with us under the name of classic.

This splendour was not confined to Rome or to Greece. Alexandria was another capital of the empire, and a general seat of literature and learning. After a time Constantinople became even more specially a capital, the first for wealth, rank, and political importance. A new empire gradually rose there, seated on the confines of Europe and of Asia. Antioch, too, was the capital of the luxurious, idle, and pleasure-seeking among the Romans.

Besides these great cities, Cologne, Paris, Treves, London, and many other important places grew up into capital towns; the Roman civilisation which spread over Asia Minor and Italy made its mark on these provincial centres. Gaul, Spain, England, became in their turn Roman provinces. Civil and military governors came thither, built temples and towns, fortified the principal cities, established courts, opened markets for the country people. Handsome houses or, as they called them, villas, with painted walls, tesselated pavements, hot-air furnaces, all that belongs to material comfort and enjoyment, were to be met with, not in London only, nor in such towns as Silchester, where you can see traces of all these details, but on sunny lawns and slopes of the New Forest, and many other choice spots on the Hampshire and Sussex coast, and in all sorts of places that command agreeable views and healthy sea air.

We know something of the general character of this old domestic art from what has been unearthed at Pompeii. That town, a small Brighton or Margate of the Romans, on the slopes of Mount Vesuvius, then a grass-grown hill such as we see in small on our downs, was overwhelmed by an unlooked-for calamity. Vesuvius suddenly burst out in showers of ashes, so fine, so dense in compression, and so continuous, that the entire town was buried many feet deep with them. The inhabitants could not all escape, and some were stifled by the sulphureous gases of the eruption. To this calamity we owe most of our knowledge of Roman life in its more minute daily details, for the whole town has been sealed up for our instruction, and in modern times it has just been unburied, and all such furniture and utensils as were of metal, and not perishable, have been recovered.

Now, this antique art, less and less exact and refined, prevailed wherever the Roman name was respected for the first five centuries of our era. Imagine London in the year 400, and you would have found a sort of little Rome. Our countrymen, when we find them in the colonies, can show us something like a slice of the old country. It was the same when we ourselves were a distant offshoot of the great Roman growth. A Roman officer in London would have invited us into a house built like a small cloister, with a garden in the middle. If large, these cloisters would have looked into it through windows which could be closed with hangings or shutters. If small, the centre part would have been closed over in winter with a moveable wooden roof, in which we should see little panes of transparent talc, or of glass, which had been made here in London under the guidance of a workman from the islands of the Adriatic. Cornices of moulded glass of beautiful colours would set off the coffers and divisions of the permanent ceiling of his cloisters. Family pictures, in folding frames, carved in wood and gilt, would be set on narrow wooden shelves

against the wall. Busts of famous personages, his ancestors perhaps, on terminal posts of white marble, would stand at intervals along the wall, or on either side of the openings into the centre garden. The lady of the house would be seated in a chair of wood resembling our ordinary dining-room chairs. She would offer her guests long couches framed in fine chased and gilt bronze laid over wood, bedded with thongs of leather, over which would be laid cushions covered with Syrian embroideries. Other seats of similar bronze work would be decorated with the heads of horses, birds, or other animals, and inlaid with damascene work of the precious metals. These would have been brought with them from Rome. A chair, heavily framed, with back and arms, panelled with carved ivory, would be pointed to as a family relic, the chair of a senator of past times, such as the chair of St. Peter in Rome. Another, with solid ivory frame, carved and gilt, jointed like two X's, but curved, as being made of two fine elephant tusks sawed through the middle, would be the curule chair of the master of the house, folded up and carried with him in his carriage when he went to preside in court and at other ceremonies. Other bronze seats without backs, but of double height, would be carried after the ladies when they went to any public entertainment, along with a wide footstool. On this she could see over the heads of the crowd. The palanquin, in which ladies of rank went abroad, would have a frame of sandal-wood richly carved, or of ebony inlaid with dies of ivory and metal work, recently imported from India. This would be shut in with sliding lattices, and well-furnished with rich curtains and cushions. It would have a long pole of oak, neatly carved by native workmen, and long enough for three bearers in front and three behind, to rest it on their shoulders, sometimes their heads.

In this way our countrymen, great bronze workers and enamellers from immemorial time, learned to add to these accomplishments such training in sculpture, architecture, and the sumptuary arts, as Roman colonists could impart.

But as to our special subject, wood-carving, and in particular the wood-carving of the Renaissance, it must be admitted that classic art gives us but meagre notions. The furniture, the figure-heads of ships, the fronts of chariots, were generally covered with bronze, sometimes cast in solid masses, sometimes thin, strengthened by a core of wood. It was chased with the graver, and generally of the colour of dull gold, often gilt.

The Renaissance artists had before them bronze and marble sculpture and marble architecture. The great temples, palaces, arches, altars, and other architectural monuments, disfigured and damaged, were yet sufficiently preserved to excite the admiration, and fire the enthusiasm of the Italians of the 15th and 16th centuries.

Meanwhile, that art which we have called classic, and in its debased state first Byzantine or Constantinopolitan, then Romanesque or Norman, as we see in the churches of the Rhine, and in the Bayeux tapestry—this art, these antique fashions, had gradually died out, and given place to fashions in which wood-carving played a conspicuous part. London, and other cities of the 13th, 14th, and 15th centuries, were constructed mainly of timber-houses; and extraordinary skill and ingenuity are seen in what remains of those structures and their ornamentation. London-bridge was covered with houses, some made, carved, and prepared in Holland —Nonsuch-house, for instance—and fitted together on the bridge. The streets were narrow, the houses framed of great beams and uprights of native oak. Along the beams, legends were carved in Gothic letters; up the angles were shallow niches, with statues of favourite saints, and over each a pierced and carved canopy. The storeys of the house projected till the top ones approached each other in the narrow streets from side to side. Inside, the walls were panelled; the ceiling, beams, and timbers had moulded edges, ending in grotesque animals. The doors were carved on the jambs and the spandrils of the arched heads. The gables were fringed with barge-boards carved on the edges.

Fine examples of the carving of those centuries are still to be seen in the stall work of cathedrals and minsters. I pointed out some last week—Winchester Cathedral, for instance—belonging to the very central period of what we will call the Pointed Style. Other examples belonged to a much later time. The stalls of Henry VII.'s Chapel at Westminster were carved when the old style was dying out. The actual tomb of that king, ordered by himself of the Italian sculptor, Torrigiano, belongs to the Renaissance. Yet, as examples of wood-carving, I do not know where to look for anything more skilfully

executed, or more bold and racy in conception and graceful in arrangement. So, again, in such large structures as the roof of Westminster-hall, with flying angels sculptured under the principal upright timbers. They are light, they float overhead, yet they are really masses of timber all well tied and fitted into the general structure. Such was the wood-work which the Renaissance found in possession. It took but limited notice of this grand structural timber art; and for what was so inventive and so dramatic in this old mixture of structural and decorative work, it substituted other kinds of excellence. I said just now that the art of the revived time was specially connected with the date of its revival, the 16th century—that is, from 1500 to 1600. Italians spoke of the time as the *cinque cento*, five hundred; but they also speak of the change in its earlier phases as the *quattro cento*, the four or fourteen hundred—the century between 1400 and 1500. The architecture, sculpture, and painting, dating between 1430 and 1500, or thereabouts, is of peculiar beauty. There is a grace and tenderness about it which did not survive the bolder, fuller, and more scientific advance which was made in the *cinque cento* or fifteen hundred century. In studying the art, the wood-carver's art among others, we should keep this distinction before us. When Michael Angelo and a host of pupils pushed their studies of old Roman art in all directions, statues, busts, fragments of old sculpture of all kinds, were continually being disinterred. Rome was half rebuilt, and numbers of these relics came to light in the process. It was a revival, a literal unburial of the old classic traditions of Rome.

This revival was very differently carried out in Italy, and in the northern countries. Gothic, or pointed architecture, never prevailed in the south to the degree it did in the north. Old basilicas, following the shape of the great halls of justice of the Romans, were very different from our northern minsters; old ruined temples, arches, and columns, met the eye all over Italy, such as were never equalled by the provincial builders of Gaul, or Spain, or England, and our great churches, castles, and manor houses, put entirely out of sight any antique buildings, if indeed any such remained among us. In the North, therefore, there remained only the great imposing structures founded by religious bodies, or by kings and princes, and all in the pointed style. The Renaissance art, both in building and in carving, in England, France, and other distant lands, retained a great deal of these mediæval traditions. In these countries, it produced that mixed style, so picturesque, and so well suited to the feudal spirits of the North which we call Elizabethan, or "*François premier*," such as you see in our noble old mansions in England; at Blois and Chambord, and a hundred other places in France; in the great Flemish cities; in Germany, and other countries.

The classic art in architecture, wood-work, and furniture is as complete as modern European habits will admit, in Italy. The broad outlines of wood structure and decoration of this kind are borrowed from architecture, and almost all the decoration consists in the carvings on columns and pilasters; on different members of framework such as bases, cornices, edges of all kinds; in the coffers or hollows of roofs and ceilings; and on the various parts which make up chests and cabinets. Let us take these in order. Columns, if on a large scale, such as the screens between the divisions of churches and halls, are generally cut into flutings. These grooves break up the heavy surface of the column, and make an agreeable play of light and shadow round it. The lower ends are sometimes filled with carved decoration in shallow relief. In smaller columns, those that support pieces of fixed furniture, such as bookcases, the entire surface is often carved with fine arabesques. Pilasters, the commoner form of wooden upright members, are, as you know, representatives or types of piers embedded, and are faced with narrow panels which are cut into their surfaces. These we fill with what are called arabesques, a series of leaves, branches, sometimes little figures of genii or fairies running in and out, with birds, animals, anything which the carver's knowledge suggests to him. All these should be composed as though they grew easily out of a bold stem, with neckings and projections resembling a great candlestick or candelabrum. Of such composition there are hundreds, some in marble or stone, some in wood, in the Kensington Museum. Any series of engravings of old monuments in Italy will contain an endless variety. There are a set of painted arabesque decorations of this kind in the Vatican, in one of the galleries that run along one of the sides of that palace. They are known by the name of Raphael, the painter who painted them with the help of his pupils.

If we look at Renaissance panelling on a large

scale, the old bedrooms, for instance, of the Louvre, the panels are divided into a base—or dado—on which the uprights rest as though it were the base of an external front. Then the body of the wall, sometimes in a series of small panels, sometimes in narrow and tall ones. Then a frieze or border along the top, finally cornices which carry the eye up to the ceiling. It is on the base, and on the frieze that carved masses, or continuous rolling scrolls with figures among them, find their place. These are carvings, which not being simple repetitions such as would occur on mouldings, but artistic compositions, call out the best skill of the carver. Then comes the roof or ceiling of the room. This has to be treated, in the first place, with reference to the structure. Suppose it is a roof as of a hall or church, with nothing above it. We have the structural roof such as we see at Westminster, and such as I will illustrate by reference to old English houses. If carved, we could only carve the larger posts, and this is often finely done; but we do not meet these roofs in Italian structure, we generally meet with carved flat ceilings. In many old rooms in Venice and other cities, the joists and timbers are shown, and are painted and gilt. In other cases these joists are ceiled over with panelling—the panels decorated with various kinds of cut mouldings—and the panel itself fitted with carved foliage, sometimes radiating foliage. I have some photographs of such a panelled roof in Milan, the panels having been moved, I believe, from a house in Brescia. Such carving as this is made in the workshop and fastened into its place. The leaves in this instance are flat, like those of flags, so as to look as light and to reflect light as much as such slight carving could.

The finest treatment of a ceiling showing the timbers, of which I can speak, is one I saw a few weeks since in Cairo. The larger timbers rest on carved brackets cusped down to the walls. The under sides are rounded, except in the middle and at the ends. Enough of the original square surface is there preserved to form a circular disc, with two half discs at the ends. These three are filled with well-turned arabesque carving of Persian design. The smaller joists are moulded with a torus and an arris, and kept square on the ends. These ends are also cut in arabesques. For valuable effect got by the simplest arrangement, I have never met with any ceiling so satisfactory. This is Arab art, it is true; but it has a close alliance with the Italian arabesque carving we have been discussing. Another way of treating a ceiling is to subdivide it by moulded bars or stiles, with carvings of a simple kind at the intersections.

How seldom do we see any attempt at a carved ceiling in any of our modern houses! How seldom! Do we see it ever? Would the London house be so much more costly if the principal room or rooms had ceilings carved in pine wood? Would the cost exceed that of the the usual ceiling—sometimes neatly decorated in plaster, gilt, and painted, and of which the painting or the whitewash must be renewed from time to time. Sheet it over with pine, subdivide it, put into panels carving to the value of some great ball or entertainment, such as perhaps is given every London season. As to cost, our public offices contain rooms on which cost has not been grudged. What part of any room is more effective than its ceiling? What part of the room, as a general rule, is so dull as the ceilings of the best rooms of the day?

As to the important subject of mouldings, I will presently show a complete set, as they are technically known, in Vitruvian architecture. These form the borders of buildings, of cabinets, of rooms, and are known by various names. The upper mouldings curve forward, and suggest the idea of an eave or protection from rain. The lower have their convex surfaces uppermost, and spread out their bases to suggest the idea of support. The sharp lines or curves that are added to the *cyma recta* and the *cyma reversa*, separate and give emphasis and effect to those members. The square bar or beam that occurs in the middle of the upper and lower set of mouldings, when mouldings are grouped together as in cornices, suggests the idea of a beam or bar projecting from the wall, both as a shelter to the house and a support to the upper surface, whether wall and roof, or ceiling; and where cornices are on a large scale this central beam is supported by bracket-shaped mouldings, such as egg and anchor, or rows of dentils, or a row of small brackets. It is important to know and observe the connection and order of these parts with reference to each other, so that the original type may never be wholly lost.

As to leaf work, such as that which forms the capital of the column, the rolling scrolls on friezes, &c., generally it is one and the same leaf, the acanthus. Many natural leaves, used conventionally, are found in mediæval carving. But in that of the Renaissance, if we except the occasional use of sprays of olive, and

those conventional heart-shaped leaves on carving mouldings, there is but one leaf found in what may be called regular harness—and that is the acanthus. It is the thistle, but treated altogether conventionally. The utmost skill is shown in the direction given to the stem, the pipings or creases in the leaf, the number and arrangement of the notchings on the edge. If you examine the capitals of the Roman temples, those of the Renaissance period in Italy, or those in northern countries, while the variety is endless, there is no mistaking the acanthus of any of them for any other leaf. So also where the leaf is broken up and used in fragments, as on mouldings and as offsets to lines, and stems such as are met with in furniture, mirror frames, and the like. A good deal of fine carving is sometimes made up of figure work and acanthus. Corners of chests and cabinets, brackets, also friezes of furniture and panelling, are made up of what are called grotesques, that is human figures half-formed and merging into leaf work, or into the bodies of animals. There are abundant examples in the Kensington Museum. If one speaks of figure carving, without doubt, a man or an animal completely formed is a more worthy object for the chisel than such a mixture, but it is not always so bold or so decorative when used in cabinets and chests, or on ornamental friezes. In such uses figures are subordinate, and are used in a grotesque form so as to make the room or the chest both decorative and interesting when seen as a whole.

I have already spoken of the composition of panels of carved work, and will show a few examples.

As to the furniture of the sixteenth century, the chests, of which many examples are to be seen at Kensington, are amongst the most remarkable objects. Italian houses have large and stately rooms, not furnished in the way we hould call comfortable; and these chests stood against the wall along with chairs, some carved, some carved and gilt. The chests are often carved with bold figure work on the angles, and with side panels containing mythological subjects, or subjects drawn from the works of Latin poets. The libraries contained cases carved, inlaid, and mounted with gilt metal work. Vasari, and other writers, give descriptions of astonishing objects of this kind made for the Medici family. Smaller objects, such as mirrors, bellows, distaffs, walking sticks, may be seen with excellent carving all over them, in the Kensington Museum. Some of these have been reproduced in the School of Carving, and were shown in the Health Exhibition last year.

Two special accomplishments seem to be required if we desire to design such carving as Renaissance decoration requires. One is that of modelling the figures, the other, some acquaintance with the common decorative details of Renaissance architecture. Most museums contain examples of the sarcophagus fronts which were made in the second and third century. The details of their ornamentation, apart from such figure compositions as are often sculptured on them, were the sources from which *cinque cento* furniture makers drew much of their decoration. Generally, also, it must be said, that though learning, properly so-called, is never common, yet the artists of those days and their workmen knew something of the literature of classic authors. Princes, prelates, merchants, and warriors were full of enthusiasm for the arts and the poetry of ancient Rome. A general knowledge may be said to have been in the air; pupils got it from their masters. Great men threw open their houses and gardens, invited young sculptors to come and study there, overlooked their work, explained the meaning of actions or the mythology of personages represented in the fragments of statues or the bas-reliefs found on the soil. Enthusiastic artists copied and reproduced marbles, medals, and gems so abundantly and so well that they passed for genuine, and even now known forgeries of those days are valued for the excellence of their design and workmanship. It is this sort of enthusiasm which produces a cultivated taste, and makes an artist and a poet of the workman.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

GROUP XIV.—APPARATUS, PROCESSES, AND APPLIANCES CONNECTED WITH APPLIED CHEMISTRY AND PHYSICS.

By Boverton Redwood, F.I.C., F.C.S.

The exhibits in this group, though less than 100 in number, are of great interest and importance. Considerable space is occupied by the representative collection contributed by members of the Society of Chemical Industry, and a large portion of this col-

lection relates to the alkali trade, among those who have furnished models, diagrams, or samples of products being Messrs. Weldon; Gaskell, Deacon, and Co.; Ludwig Mond; Brunner, Mond, and Co.; James Muspratt and Sons; Joseph Gamble and Sons; Hargreaves and Robinson; Bell Brothers; and James Mactear.

The principal improvements effected in alkali manufacture since Professor Hofmann recorded the position of that industry in his masterly report on "Chemical Products and Processes at the 1862 Exhibition," have been described by Professor Armstrong in the official catalogue of the present Exhibition; and in the papers contributed by Mr. Walter Weldon to the Society of Chemical Industry we have an authoritative statement of the present condition and prospects of the manufacture of soda and bleaching powder. Nevertheless, it may be well to refer briefly in this report to the rival processes for the manufacture of carbonate of soda, before proceeding to notice in detail the exhibits already referred to. The Leblanc process of soda manufacture consists, as is well known, in decomposing common salt with sulphuric acid, thus producing hydrogen chloride and sodium sulphate. The hydrochloric acid is utilised in the manufacture of bleaching powder, and the sodium sulphate is converted into sodium carbonate and alkali waste. A very great improvement in the manufacture of bleaching powder was effected by the introduction of the Weldon process for the regeneration of the peroxide of manganese from the liquor remaining in the stills after the chlorine has been evolved. This process has proved to be of a value difficult to overestimate. Among the troubles with which the manufacturer of Leblanc soda has had to contend is the nuisance created by the deposit of vast quantities of sulphur waste, and several processes have been devised for utilising this residue. The ammonia process of soda manufacture consists in causing carbonic anhydride to act upon a solution of common salt in aqueous ammonia, whereby sodium bicarbonate is produced, the ammonia being subsequently recovered from the mother liquor. This process is far more economical than the Leblanc process, and is largely taking the place of the latter, especially in France and Germany, where, according to Mr. Weldon, no less than 44 to 45 per cent. of the total quantity of soda manufactured at the close of the year 1882 was obtained by the ammonia process. While, however, the Leblanc process remains the great industrial source of hydrochloric acid, and chlorine continues to be produced from this acid, the ammonia process cannot wholly take the place of the older method of producing carbonate of soda.

The exhibit of Messrs. Gaskell, Deacon, and Co., comprises diagrams of apparatus used in Deacon's chlorine process, a coil furnace for the decomposition of ferrocyanides in alkaline solutions, and a machine for making bicarbonate of soda. The chlorine process consists in passing a current of hydrochloric acid gas and atmospheric air over fragments of firebrick previously soaked in solution of copper sulphate and dried. Under these circumstances the oxygen of the air combines with the hydrogen of the hydrogen chloride at a moderate temperature (about 500° C.), and the chlorine is liberated. The copper salt remains unaltered, and the process is continuous. In the second process illustrated, alkaline solutions containing sodium or potassium ferrocyanide are subjected to the action of atmospheric air, or atmospheric air and carbon dioxide. The solution is then exposed to a temperature of 350° to 360° F. by forcing it, under a pressure of 200 to 300 lbs. per square inch, through a coil heated in a furnace. The iron, which is precipitated, is separated, and the sodium carbonate obtained by evaporating the solution. The monohydrated carbonate thus produced is converted into bicarbonate, by exposing it to carbonic acid in the machine already referred to, which is a revolving iron cylinder supported on hollow trunnions, through one of which the gas enters, while superfluous moisture escapes through the other.

In addition to a model of plant for the manufacture of chlorine Mr. Weldon shows two specimens, illustrating the oxychloride of magnesium chlorine process, wherein magnesium oxychloride, formed by adding MgO to $MgCl_2$, $6H_2O$, fused in its water of crystallisation, is heated in a current of air, chlorine being evolved and MgO remaining.

Mr. Ludwig Mond's exhibit relates to his process for the recovery of sulphur from alkali waste, which consists in promoting the partial oxidation of the sulphur calcium compounds by forcing air through a mass of alkali waste, washing out the soluble compounds thus formed, and decomposing with hydrochloric acid. A modification of this process is shown by Mr. Mactear, who also contributes models and diagrams of his improved furnace for the calcination of alkaline carbonates.

Carbonate of soda, manufactured by Solvay's ammonia process with Mond's improvements, and bicarbonate of soda by Mond and Jarmay's process, are exhibited by Messrs. Brunner, Mond, and Co.; while Messrs. Bell Brothers, demonstrate the result obtained by Schloesing's ammonia process.

Messrs. Hargreaves and Robinson show a model of the apparatus used in their process for the manufacture of sodium sulphate directly from common salt. The object of the process is to convert salt ($NaCl$) into salt-cake (Na_2 SO_4) without the use of oil of vitriol. Common crystallised salt, mixed with ground rock salt, is moulded into small cubes, put into cast-iron cylinders, and heated to 800° to 1100° F. Sulphur dioxide, derived from burning pyrites, mixed with air and steam, is passed into the cylinders, sodium sulphate and hydrogen chloride gas being formed.

Chlorate of potassium, made by Muspratt and Eschellman's process, and chlorate of sodium, produced directly from "octagon liquor" (calcium chlorate and chloride) by Pechiney's process, are

contributed respectively by Messrs. James Muspratt and Sons, and by Messrs. Joseph Gamble and Sons.

Passing now from the consideration of that portion of the collective exhibit of the Society of Chemical Industry which relates to the alkali trade, attention may be directed to the samples of sulphuric anhydride and monohydrate shown by Messrs. Chapman, Messel and Co., and to the condensed sulphur dioxide in glass syphons and copper drums, of which Messrs. A. Boake and Co. are the exhibitors. The latter firm also contribute a collection of sulphites, some of which are novel.

Fine chemicals and pharmaceutical preparations are shown by Messrs. Howards and Sons, May and Baker, Hopkin and Williams, Mackey, Mackey and Co., Thomas Christy and Co., and by Mr. Robert H. Davies, of Apothecaries'-hall. These exhibits are characterised by the excellence rather than the novelty of the products; but the camphor, compressed into transparent blocks by hydraulic pressure, shown by Messrs. Howards and Sons, and the transparent tablets of the same substance, produced by a process of sublimation, carried on by Messrs. May and Baker, are worthy of special mention.

In a separate building, erected in the neighbourhood of the Old London street, Messrs. Brin Frères show in practical operation, on a tolerably large scale, their apparatus for the industrial separation of oxygen from atmospheric air through the medium of barium oxide. The chief novelty in the process seems to be the use of pressure during the peroxidation, and an exhaust during the deoxidation. The furnace in which the barium oxide is heated is provided with pyrometric bars, which automatically close and open valves in the pipes supplying air to the fuel, and the temperature is thus regulated. It is claimed that, contrary to early experience, the barium oxide employed increases in power of taking up and parting with oxygen by use, so that, while one kilogram of the material will give in the first operation 25 litres of oxygen, the yield is increased to 68 litres after eight days continuous use. It is proposed to convert the separated nitrogen into ammonia, by passing it in a moist condition over a mixture of coal and caustic baryta heated to 150° C.

Specimens illustrating the alum process for the removal of potash from saccharine solutions are shown by Messrs. Duncan and Newlands. The presence of potassium salts in beetroot syrup prevents the crystallisation of a portion of the sugar, and the process in question consists in removing these salts by adding to the saccharine solution sulphate of alumina in the cold. More than 4,500 tons of potash alum are stated to have been thus made during the past few years, while the yield of sugar has been considerably increased. The strontium process of sugar manufacture, which can hardly be said to have passed through the experimental stage, is illustrated by specimens exhibited by Bolton and Partners; while Messrs. Edward Packard and Co. show "Ehrmannite," a product rich in phosphoric acid, used in the Ehrmann-Bernard-Icery process of clarifying sugar-cane juice.

Proceeding now to the consideration of exhibits relating to the treatment of coal, and taking first those which illustrate the production of coal-tar colours, we come to the exhibit of the Badische Anilin and Soda Fabrik. This remarkable collection, which is undoubtedly the finest of any included in Group XIV., comprises more than 200 specimens, among which are acid magenta, benzaldehyde-green (and other derivations of triphenylmethane), crystallised methyl purple, Victoria blue, auramine (and other products synthetically prepared by means of oxychloride of carbon), eosine (and other phthaleïnes), resorcine, artificial alizarine, alizarine orange, alizarine blue, artificial chinoline, oxy- and methoxychinolines, thalline, cinnamic acid, artificial indigo, methylene blue, aromatic nitroso-compounds, azobenzol, benzidine (and derivatives), α and β naphthol (and derivatives), naphthol yellow, fast red, anisol red, beta naphthylamine, &c. The catalogue of the exhibit is admirably arranged in the form of a printed book of twenty-seven pages, containing the dates of the various discoveries, and references to the patents and literature, the specimens being divided for the purposes of this catalogue into the following nine groups:—

1. Derivatives of triphenylmethane. Synthesis by means of benzyle derivatives.
2. Synthesis of the rosaniline series by means o oxychloride of carbon.
3. Phthaleïnes.
4. Anthracene, phenanthrene, carbazol, acridine, and their derivatives.
5. Chinoline.
6. Artificial indigo.
7. Methylene-blue, 1877.
8. Azobenzol and its derivatives.
9. Naphthol derivatives.

Of similar character, but less completeness, is the exhibit of Messrs. Ivan Levinstein and Co., who contribute over 100 specimens, including Blackley-blue (the sodium salt of the disulpho acid of phenylated rosaniline) which is so largely used for tinting and dyeing paper, the firm of Levinstein claiming to have produced of this dye over 1,000 tons, of a value of nearly one million sterling. The manufacture, by improved processes, of malachite, or methyl, green, and brilliant, or ethyl, green, is also illustrated, the products exhibited being the zinc chloride double salts, with the hydrochloric salts of the tetramethyl and tetraethyl diamedo-triphenylcarbinol, and the oxalates of the latter. The oxalate of ethyl green is shown to be capable of beautiful crystallisation.

The large and interesting series of specimens exhibited by the British Alizarine Company effectively illustrates the important manufacture, from the coal-tar product, anthracene, of the tinctorial substances which were formerly obtained from madder, viz., alizarine, anthrapurpurine, and flavopurpurine. The exhibit is divided into five sections:—

1. Specimens of the madder plant, living and dried.

2. Specimens of cotton fabrics printed, and dyed with madder products, some of considerable value and antiquity, and fine specimens of the old painted and stencilled work.

3. Set of specimens of the manufacture of the company, illustrating some of the thirty to forty stages of the process of converting the crude anthracene into commercial alizarine.

4. Specimens of the various products chemically pure.

5. Collection of yarns, Turkey-red cloths, and cotton fabrics dyed and printed with alizarine alone, and in conjunction with other dyes.

Mr. S. B. Boulton, chairman of the British Alizarine Company, states that the present yearly consumption of alizarine in Great Britain is about 3,400 tons of 20 per cent. strength (the strength at which it is now sold), or 6,800 tons of 10 per cent. strength. According to the best authorities, a ton of 10 per cent. alizarine does the work of nine to ten tons of madder root. Taking the lowest computation, the 6,800 tons of alizarine at present annually consumed in these islands, therefore, represents 61,200 tons of madder. The cost of this quantity of madder, at the average prices of the fifteen years ended 1876, would be £2,907,000, while the cost of the alizarine is given as £456,960, showing a saving of £2,450,040 per annum to textile manufacturers. It is well known that the discovery of the process on which the present alizarine industry is founded, was made simultaneously by Dr. Perkin and by Messrs. Caro, Graebe, and Liebermann.

The exhibit of Boulton's process of creosoting timber, by Messrs. Burt, Boulton, and Haywood, adjoins that of the company of which, as already stated, Mr. Boulton is chairman. The ordinary process of creosoting consists in placing the timber in a closed cylindrical vessel from which the air is first exhausted, and into which the creosote, heated to 100° to 120° Fahr., is afterwards admitted under pressure. This process answers fairly well if the timber be dry, but fails if the timber be saturated with moisture. Under S. B. Boulton's system, the creosote is introduced at a temperature a little above 212° Fahr., and the action of the air-pump is continued until the moisture contained in the timber has been sufficiently removed, and replaced by creosote. The exhibit consists of a model of the apparatus employed, and specimens of timber thus preserved. Among these specimens are railway sleepers, said to have been in use for thirty years, which show but little decay. Two of the beech sleepers are stated to be from a parcel of 6,890 creosoted by the firm in 1865-6 for the West of France Railway Company, and removed from the line in 1885, when no less than 6,545 of the number were found to be perfectly sound, according to the report of the Company's engineer.

Other exhibitors of coal-tar colours are Messrs. Brooke, Simpson, and Spiller, who show Nicholson blues, regina purple, XL soluble blue, non-mordant cotton blue, citronine, golden roseine, pure scarlet, alkaline green, and Albany and acid maroon; Messrs. F. C. Calvert and Co.; and Messrs. Roberts, Dale, and Co.

An improved process for the manufacture of products from coal is illustrated by the specimens shown by Mr. G E. Davis. In this process, the coal is distilled at a low temperature, so that not more than from 7,000 to 8,000 cubic feet of gas are made per ton, the gas yielded being rich in benzol, and containing comparatively few products of the paraffin series. The products of the distillation are conducted through condensers, washers, and scrubbers, the scrubbing water being warmed to minimise the solution of the benzol and other hydrocarbons, and also of the sulphuretted hydrogen. The cooled gas is then brought into contact with cooled hydrocarbon oil, and the more volatile hydrocarbons being thus taken out, the gas is used as fuel, and the products of combustion brought into contact with ammonia, whereby ammonium sulphite and sulphate are formed. The hydrocarbons dissolved by the oil are separated by distillation, and the oil thus rendered again fit for use. One ton of coal thus treated at 1,200° F., as registered by Siemens' electrical pyrometer, is said to have yielded 16 gallons of tar, 37 gallons of ammoniacal liquor, 12½ cwt. of coke, and 7,000 cubic feet of gas, containing four gallons of 90 per cent. benzol, and enough sulphur to enable it to be used for the manufacture of sulphate of ammonium.

The specimens of nitro- and dinitrobenzol, shown by Messrs. Sadler and Co., were obtained by another method of treating coal-gas. In this process the gas made in the ordinary way, or gas which has been super-heated with the object of increasing the percentage of benzol, is separated from tar, passed through sulphuric acid, and then through a mixture of sulphuric and nitric acids, whereby the benzol is converted into dinitrobenzol.

The Jameson process of treating coal was illustrated by models and specimens at the Health Exhibition, and in the present Exhibition are models and diagrams of the Simon-Carvès coke ovens, as well as samples of the coke and residuals obtained.

(To be continued.)

The number of visitors to the Exhibition for the week ending Tuesday, 18th inst., was 140,638. Total since the opening, 2,215,931.

Correspondence.

PHILOSOPHICAL INSTRUMENTS AT THE INVENTIONS EXHIBITION.

In your issue for Friday, August 7th, 1885, I beg to point out some errors in the criticism of calculat-

ing machines, pp. 943, 944, by Professor H. M'Leod. The locking arrangements having been eliminated from my machine, are replaced by simple adjustable tension springs, the action of which is rather doubted by the Professor; but which have stood the test of six years' working, and never failed to keep the machine correct.

In another instance, he says that "at other times the fixity of the number discs depend on springs, which Mr. Tate has modified, and Mr. Edmundson has entirely eliminated." Mr. Edmundson has lately been obliged to apply springs (of a different form), the action of which is rather doubtful, to keep his number discs in their proper position.

S. TATE.

26, Gloucester-street, Clerkenwell,
August 12, 1885.

THE LIBRARY.

The following have been added to the Library since the last announcement:—

Biadego, G. B.—Monographie Techniche: Ponti in ferro ad arco (Ponte Nuovo di Verona ecc.); Ponti in ferro a stilate metalliche e fondazioni con pali a vite; Ponti in muratura romani e medioevali ed a grandi luci; Il fiume Adige e le sue piene. (Verona, 1885.) Presented by Carl A. Thimm.

Bowman, F. H.—The Structure of the Wool Fibre in its Relation to the Use of Wool for Technical Purposes. (Manchester: Palmer and Howe, 1885.) Presented by the Author.

Bros, W. Law.—The Presidential Address delivered before the Sidcup Literary and Scientific Society. (London: Stacy and Cook.) Presented by the Society.

Buckton, Catherine M.—Our Dwellings: Healthy and Unhealthy. (London: Longmans, Green, and Co., 1885.) Presented by the Publishers.

Carpenter, William Lant.—A Treatise on the Manufacture of Soap and Candles, Lubricants, and Glycerin. (London: E. and F. N. Spon, 1885.) Presented by the Author.

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Proceedings of the Society.

CANTOR LECTURES.

CARVING AND FURNITURE.

By J. Hungerford Pollen.

Lecture III.—Delivered March 23, 1885.

The Seventeenth Century.

Last week I reviewed the carver's art in the period known as that of the Renaissance—the *cinque cento* of the Italians. In all that concerns our present inquiry the excellence of the period was so great, and the variety of graceful and beautiful decoration so inexhaustible, that I could do little more than point out a few examples, enough to stimulate curiosity, not to satisfy it. We see a few admirable examples of carved chests, seats, cabinets, and other furniture; fragments of screens, isolated columns, and so forth, in our museums; they are perfect as examples. But if you travel into Italy, the home and seat of these splendid works, it is not fragments, but entire interiors that will meet your eyes. Sets of church stalls, with figure-subjects behind each seat; screens, great book-desks, and other furniture. Churches retain what has once been erected within their walls. The halls and galleries of private houses have not been so fortunate. New generations have followed the fashion, and old carved furniture, if not broken, has been sold and dispersed. We find here a chair, there a cabinet; these are bought up. We meet them under our glass cases at Kensington and elsewhere, and wonder what may have been their history from the 16th to the 19th century.

We are now to consider the age that succeeded. The great master workmen, who learned under sculptors and painters of well-known fame, and at the orders of the Florentine, Roman, Milanese, and other Italian princes, produced schools of carvers. They went north, east, and west. Much of the early Renaissance carving in France and in England was the work of Italians encouraged to settle amongst us by Henry VII., Henry VIII., Mary, and Elizabeth. It was natural that we, living on an island, and often at war with our nearest neighbours, should be among the last to feel the effect of a great European change. The 16th century in England was a very stormy time; society was going through a great change, and the new order of things had not settled itself into any regular condition. The new style of architecture was encouraged by the court and great men. There were new families risen to wealth and rank on the ruins of older stocks, and they built themselves palaces and houses in the new style. In the country generally it was different. Here and there families, from fear of proscription and persecution, lived in the quietest way in old manor houses, in granges, or other houses of former tenants of monastic property; while great earls and barons still retained their old feudal castles and towers, and kept moats and drawbridges, uncertain when they might want such protection.

The 17th century was more peaceful. James the First was not warlike, and he did not encourage the jealousies of these great feudatories. He exhorted the landowners and squires to live on their estates, and to enjoy their gardens, their parks, and their forests, away from the intrigues of court life. We owe to the first half of the 17th century most of those noble country palaces, which have continued to our own times and are the glory of every county in the kingdom.

I draw a marked distinction between town and country houses. To understand the splendour, the conveniences, the wants, to be provided for in fitting them up and furnishing them, one should remember this distinction. In a great city—in London for instance, society is headed by a king or a queen. As those personages are supreme in the State, so they override their subjects in social life. Great lords, however high their rank, ministers and merchants, however rich, are too many in number, and too equal as to dignity or fortune, to be of any special consequence individually. But they are far different when they own parks

and woods, and broad acres in Kent and Yorkshire, or Cheshire, or Norfolk. They have elbow room there, and fill places of honour; administer local affairs, and live for their friends and their neighbours. The hospitalities of London are rather what we term gaieties than hospitalities. Houses are not of a size to take in poor relations and friends from a distance. There are hotels and lodgings on every side. The furniture of town houses follows the changes of fashion. There is less room for massive objects, such as presses and dressers—those fine monumental pieces which carry our memories back to other times. In the country house this bold carved furniture is in its place. And I take the 17th century as the period when country houses, as we now see them, were mostly built. They are not squeezed into a street or a square, nor carried up to numerous storeys. They have plenty of space to spread out for such accommodation as may be required. They go more often by the name of halls than of castles or manors, though many of them stand where castles have been before, till such strong places were wanted no longer. This title, "The Hall," was not given without reason. The houses of the early middle ages had but one room, the hall, and these old mansions retained it above and before all other features of the house. It was where neighbours and strangers, as well as the entire family, were entertained. It was close to the entrance, so that you might enter out of the night or the storm, and be welcomed at once with fire and food. These vast rooms retained very often the old mediæval timber roof and lantern. A passage was taken off the end of them, leading from the entrance door to the body of the house, and giving access to the hall on one side, and the kitchens and offices on the other—a stately and convenient arrangement. These "halls," these old homes of hospitality, have retained the savour of the best and kindliest traditions of old English life. They have to this day a remarkable popularity. These old baronial halls, so stately, so full of repose, figure continually in romances and in the pictures of artists. Numbers of such country houses are continually being built, and I call attention to this fact, for, while architects seem at no loss for models and designs for the shell of such buildings, I rarely meet with anything like a design of interior woodwork of the hall that is really felt and carried out in the spirit of the old halls, numerous and varied as these constructions are. The hall, then, being the principal room of the typical country house, and that which is most seen, and contributes so much to the character of the mansion, it is worth considering the carving which will be most effective for its decoration.

The most important features are the screen which partitions off the entrance passage or lobby, and the fire-place, and then the panelling of the walls. Any drawings or engravings of old country houses will show us examples of these features in great variety.

To begin with the screen. These screens of Elizabethan halls are not mere frameworks of panelling, such as we see in some old college halls, made during the reign of mediæval-pointed architecture—simple reticulations—as, *e.g.*, at Hampton-court, but full of salient features. There are, in the larger screens, two entrance arches, a centre to hold a sideboard between, and corresponding spaces between these entrances and the side walls on either hand. There being a gallery or passage over the entrance leading to the first floor rooms, this gallery is fronted by an upper tier of arches. The entire structure is generally massive, full of striking features, coarse in execution, being carved by country workmen, but with a masterly feeling for effect, and for the effective use of grotesque and bold detail.

Fire-places came into general use in the 16th century. In earlier halls the hearth was in the middle of the room, and the smoke found its way to the timber roof, which it blackened, and then through the lantern in the centre to the open air. The more refined habits of the 16th century led to a better arrangement, and the fire-place was universally constructed in the wall, and the smoke escaped up a chimney. There over the wide hearth the finest carving was placed.

These chimney-pieces are in great variety. The more elaborate are complete architectural frontispieces, something like a triumphal arch in two storeys, the lower on columns, or on bold carved pilasters, sometimes baluster-shaped, with human heads, and conventional shoulders, and then contracting towards the base. This is the old terminal figure of classic sculpture in a dress suitable to the bold and massive character of the general woodwork of the Elizabethian style. The upper storey rests on a broad and solid entablature, and is subdivided into three or more parts by columns, or by pilasters of similar character. Sculptured bas-reliefs, often of histories taken from the Scriptures, or compositions of an allegorical character, fill up these

spaces. In smaller fire-places there may be but but one large panel, and that filled with heraldic achievements, as we have seen in some of the photographic illustrations thrown on the screen. None of this carving, with the exception of figure compositions, is of any very difficult execution. The solidity of the woodwork leaves room for, and requires a corresponding boldness in, the use of the chisel. The mouldings are large; the work on the salient parts, such as columnar supports and brackets, is in deep cuttings, giving full relief to the prominences; bringing out light and shade in well-measured proportions; showing the constructive arrangement of the supporting and dividing members, and suggesting even from the furthest ends of the room that some careful work is expended on the spaces they enclose. These structures produce their due effect at once from any distance at which we can see them. I may call attention to the variety of smaller constructions of this kind, made to suit small manor and town houses, of which the 17th century woodwork gives continual examples; many are found without carving properly so-called, the work of the joiner only. They are not supported by side columns or piers but by an architrave stretching across the stone jambs of the fire-place from the panelling of the walls on either side; with turned columns resting on it, and with oval or circular panels in the middle, or a panel following the lines of a pedimental window or doorway. In describing some old mediæval chests the other day, I called attention to the ornamental ironwork which binds the angles and adds strength to locks and hinges. We meet this ideal frequently in the wookwork of the 17th century; straps with rounded nail heads are found represented in extra thicknesses of material so as to give a certain decorative addition to joiners' work on which no carving, properly so-called, is to be found, or nothing beyond mere flat sinkings made by the carpenter. Here are examples from a house in the city of London.

I should weary you if I attempted to follow the varieties which may be noted in regard to these chimney-pieces of simple and economical construction.

One more feature of old Elizabethan houses must be noted; I mean the staircases. If the halls are so grand a feature in the general disposition of the lower part of the house, the staircases which connect it with the upper storeys are scarcely less so. Accordingly we find carving on stair balusters in great variety. Stairs being arranged generally in a square or oblong space, in order to have risers and steps as low in height and as easy of ascent as possible, have to be laid out with frequent turns and landings. The handrails have to come to a finish at each turn, and to start afresh at each new flight. The post which ends each set of rails is called a newel. Sometimes, for want of sufficient support to the flight above, the newels are continued from the ground to the upper flights. Generally the necessary support is found in the short pieces of floor which form the landings. The newels in many of these 17th century houses are massive posts, carved with geometrical sinkings —with or without foliation—and surmounted by statuettes of human figures, animals, heraldic supporters, and the like. At Blickling-hall, in Norfolk, these figures represent natives of all countries of Europe in their national dresses, carved in pear-wood with much spirit. Here are others taken from examples engraved in Nash's *Mansions*. They are some 3 feet high, and bear a due proportion to the newel posts on which they are mounted. Then, again, as to rails and balusters. In many old houses the balusters are merely turned out of 3-inch or $3\frac{1}{2}$-inch posts, with bosses and neckings. The newels too, surmounted by a turned ball, or a reversed acorn. In houses of more pretension, the balusters are arches, supported on terminal columns or square piers, the arches having bold key pieces carved in their centres, as in the figures thrown on the screen. The rail in such cases has the massive proportion of a beam, and the upper surface is scored by deep cuttings and bold roll mouldings to give life and lightness to the mass, and afford convenient hold to the hand.

As to the furniture, the cabinets, tables, and chairs of that age. The cabinets are architectonic compositions, answering to the chimney-pieces, with columns or pilasters on the angles, and the panels of the doors are carved with little reliefs representing the virtues, Prudence, Temperance, Justice and Mercy, Faith, Hope, &c. It is worth noting that these tall cabinets came in considerable numbers from Flanders. Mechlin seems to have had a special trade in these pieces of furniture, which it retains to this day, most of our modern Elizabethan furniture sold in Wardour-street being of Belgian make. In the 17th century the fronts were carved and put together, and were floated down the canals of the Low Countries to Bruges and Antwerp, and thence imported to Harwich and other

on the east coast of England. The cabinets were completed by our own joiners, were copied, and the general fashion followed in many parts of the country. Bedsteads, dressers, and presses are still met with in old farm and manor-houses, made at home from these imported models.

One more piece of furniture is noticeable from its effective massiveness, the table of the 17th century hall. In the Middle Ages, the hall was put to so many uses that the tables were generally laid on trestles, which could be folded and removed after dinners and suppers. In the 17th century halls they are no longer moveable, but are of $1\frac{1}{2}$ inch or 2 inch oak plank, and stand on legs swelling into immense acorn-shaped bulbs in their middle. These bulbs, in good examples, are carved with acanthus work, and the upper frame of the table with interlaced strapwork.

These screens, fire-places, stair balustrades, and huge oak tables, seem to me essentials of the country-house hall, if it is to retain its old historic impress, so dear to most Englishmen —to me specially so. I have already noticed that piece of carving which is so effective on exteriors, the carved barge-boards which finish gable ends, so often required and so badly executed in these days. All the works here noted can be suitably carved by moderately skilled hands; excessive neatness, sandpaper, and the varnishing brush are neither needed nor would they be in place in country-house work of this kind. A large number of such houses are in process of erection yearly. I have seen many. The notion of sending for five or six carvers, and finishing them really in the old manner, rarely, if ever, seems to be entertained. It seems to have passed out of the mind of our architects, yet it would not be more expensive than most of the costly joinery of the day.

There is a great deal to be said about Elizabethan wall panelling, the shapes and dimensions of its divisions, and the mouldings with which it is decorated; but I should exceed the time at my command were I to enter on this part of my subject. A change of great importance came over our own national architectural history under the influence of Inigo Jones, Wren, Grinling Gibbons, and their contemporaries. Jones was nearly thirty years old when James I. came to the throne. His education seems to have been Italian. He became known in this country through Anne of Denmark. It was in 1616 that he became surveyor and architect to the Crown. The Banqueting-house in Whitehall is, as you know, part of his projected royal palace. Part of Greenwich-hospital, public buildings in one or two parts of England (the Town-hall at Abingdon, I rather think, is one), and several private houses are from Jones's designs. Amongst his private houses, Wilton-house, near Salisbury, deserves special mention; Barrington-house, in Gloucestershire, is another. Palladio seems to have been his favourite master. His architecture is simple, bold, massive. It gives but little opportunity for the carver beyond admirable moulding and cornice acanthus work. You trace certain favourite details, viz., three acanthus buds or flowerets, which bend over the brackets of his chimney and ceiling cornices. Other peculiarities would also be observed by any carver whose task it was to supply damaged portions of the carving he allowed about his architecture.

Wren was the next great light of architecture in England. The carver whose name is associated more particularly with the name of Wren is Grinling Gibbons. He was first heard of by Evelyn, in 1670. A pot of flowers which he did outside of his window in Belle Sauvage-court was so delicately carved that the leaves and blossoms shook with the rumbling of passing coaches and carts. The carving of Gibbons consists of hanging-swags, composed of fruit and flowers, with birds and animals among them. There are examples to be seen over the communion tables of St. Paul's cathedral and of St. James's, Piccadilly, where the marble font, with figures of Adam and Eve, is by him; over the doors and chimney-pieces of the state rooms at Hampton Court, where also the carved mouldings, by other hands, are well worth careful examination. Chatsworth-house, and Petworth-house, in Sussex, have excellent examples of the best carving of Gibbons. I showed a photograph of a portion of the carving at Petworth in my first lecture. Here are others more successfully taken. These carvings surround a series of full-length portraits. They represent hanging trophies of the attributes of the seasons, including ears of bearded wheat, cut with the utmost delicacy; musical instruments, with low reliefs on their surfaces; medals, one said to represent Gibbons himself; lace Steinkirk cravats; classic vases, with figure work on their sides; an immense variety of objects. All these, finely as they are cut, are not left without substance at the back; and this apparent undercutting, without loss of sufficient solidity and unity with

the mass to which the prominent parts belong, should be well studied. It has been impossible to do justice to this aspect of the work in a photograph, or to show where direct imitation of nature has been avoided. It must be borne in mind that conventions are resources by which the artist suggests all that he has to teach the beholder, and so as to satisfy him, yet without overstepping the limits within which his art is necessarily confined. These conventions are justified by their effects. Carvers will do well to study the conventions or treaties between the art of carving and the impossible, which have served the purpose of so consummate an artist as Gibbons. His work was generally executed in limewood. He died in 1721, and left a school of excellent pupils, to whom we owe the fine fire-places, door-heads, picture and looking-glass frames of the first half of the last century.

It is to be observed that the more correct and Italian architecture of Jones and Wren, stately as it is in churches and great public buildings, is cold, sometimes dull, when compared with the vivid and dramatic inventiveness of the earlier years of the century. I am speaking here of their interiors only. The beautiful carvings of such an artist as Gibbons would set off any woodwork. But it is a sort of parasite, an extra, added to the current lines and proportions of the architectural woodwork, not an integral part of it.

Something ought to be said of the outdoor furniture of those days. We alluded to the rumbling of coaches. In the days of the Stuart kings, of Louis XIV. of France, such means of conveyance had become of general use. Henri IV. was stabbed by Ravaillac in his coach, but it was the only one he had. Louis XIV., we are told, met our King James, when he took refuge in France, with a cavalcade of a hundred. The Stuart kings, and the potentates of their day, drove about London and went down to their country estates in coaches, beautifully carved and gilt. If you desire to see the only example to which I can point of the coach of the 17th century, go and see that of the Speaker, at Westminster. It is mounted on four groups of allegorical figures. The framework of the body is of oak, carved with foliage and figures, almost detached. Figures of the virtues are placed on the angles. Allegorical figures support the driving-box and the hind standard from which the body is suspended. I have given a full description of it in "Ancient and Modern Furniture." In my judgment it far surpasses any of the ceremonial coaches still used in state processions. It is said to have been used by Oliver Cromwell.

Besides the carriages, we should remember what frequent use was made of boats. Hampton-court, Greenwich, Whitehall, were all palaces actually on the River Thames, and the Court made regular use of the river as a highway. The beautiful ceremonial barges of the Lord Mayor and the City companies have ceased to row up and down the river. They are handsomely and effectively carved. What have the City Corporations done with them? They are worth house room in their great halls. What was carved in small on Thames barges figures still more effectively in the old designs of ships the Royal Navy. Figure-heads, stern windows, decorative leaf and scroll work round the upper posts of the ships of the time of the Charleses and James, have dwindled down to a band of cable carved round the royal yacht of the present reign.

During a great part of the 17th century, Louis XIV., or the Great, as he loved to be called, reigned in France. In the arts of peace and war his country held, perhaps, the greatest place in Europe. He was the figurehead of the great European family in all matters regarding ceremonial splendour and court life. His palace and gardens, his court festivals, his carriages and establishments, were on a large scale, and went far to set the fashion to neighbouring nations. We owe much of the large, bold, but somewhat cold interior fittings of our town houses to the pompous manners and stiff ideas of this great man. However, in the matter of furniture, there are two or three broad features worth noticing, which distinguished the times of Louis, and set corresponding fashions going among ourselves. First, the great use of silver. That metal found its way in great quantities from Spanish America into Spain, and into all provinces under Spanish dominion; the Low Countries, for instance, and the kingdom of the two Sicilies. We find in Louis's reign that table plate of massive proportions came into use among rich French families, and the same may be said of our own country. Not only table plate, but tables, mirror frames, and other furniture were made of silver. A massive frame of this kind belongs to the Queen, and is at Windsor Castle. The furniture of Whitehall, even the toilet services and basins in the bedrooms of gentlemen and ladies of the Court, were of silver. Much of it, both from the royal

and private houses, found its way to the mint and the melting pot during the Civil Wars.

Another fashion that much concerns our subject was the use of large sheets of looking-glass. Silvered plate-glass, with bevelled edges, sometimes with little figures cut on the surfaces in intaglio were first made in Venice. For many years these mirrors were of small dimensions, 5 feet being the largest. Indeed, till late in the 17th century, large looking-glasses were made up of several separate pieces, the divisions between the plates being covered by subordinate lengths of gilt mouldings within the general frame. Louis covered the walls of his great *Salle* at Versailles with looking-glass panels. A great variety of enclosing frames were designed for these large glasses. Some are of pieces of plate-glass, white and coloured, cut into curves and other shapes, and fastened by brass pins through minute holes drilled with a diamond. Generally, looking-glasses were enclosed in frames of wood carved and gilt. A quantity of carving designed and prepared especially for gilding became a prominent feature of interior furniture, in Louis XIV.'s reign in France and other countries. The work of the Italians, in Florence and in Venice particularly, is bolder, more graceful, and more massive in general character than that of the French, but is rarely heavy. That of French carvers, on the other hand, is lighter and somewhat more gay.

The name of Louis Quartorze is commonly given to a style of light, somewhat affected and fantastic, curvature, which properly belongs to the fashions of a later reign, a less severe system of manners, and times altogether irregular, and showing signs of decay and corruption. But the better art of this kind is exercised in the graceful use of the acanthus leaf, placed so as to form luminous breaks and diversions from the monotony of mere lines of moulding. Picture frames of the time have broken corners, carried out on each of the four angles of the frame; they are sometimes called hammer-headed. We know them also as Vandyck frames, as most of the pictures of Vandyck are mounted in this fashion.

But besides gilt mirror and picture frames, furniture, such as tables, chairs, and sofas, began to be carved and gilt in the same way. Tapestries specially designed for the backs and seats of chairs were upholstered on these gilt frames. All this kind of furniture received a wide development in the century that followed.

Another invention belonging to the 17th century is that furniture which takes its name from Boulle. André Charles Boulle was born in 1642. He was employed on the furniture of the palace of Versailles. His work, whether he invented it or not—for there are some grounds for doubt—is a particular kind of veneer made in tortoiseshell, and very thin brass. The designs of his cabinet fronts are partly borrowed from the outlines of antique Roman altars. In those cases salient ornaments in brass works, cast and tooled with the graver, are superadded. These mounts are massive when compared with the fine lines, reticulations and pattern work of the general surface. They are masks, or volutes, or claw feet. Sometimes they represent medals, casts taken from the commemorative medals struck in honour of victories and other events of the king's reign. Veneers, as you know, are thin slices cut by watch spring saws through two thicknesses of wood or one of metal, and the other of shell. A double set of grounds and two sets of patterns are so produced. They are counterchanged, and then fastened with thin glue on the wood below. Great pressure is used to exclude the air and maintain perfect cohesion between the veneer and its bed, till the glue is entirely hardened. The brass work is further secured by fine pins of the same metal, the heads of which are afterwards filed down to an even surface with the rest of the work, and chased over. Perhaps, no furniture, during the period we include under the name of Renaissance so nearly resembles the splendid metal furniture of antiquity. The work is produced by modern cabinetmakers, generally imitated from old pieces, but the cost of production is heavy. The prices at which two old upright presses of the 17th century were sold at the Hamilton sale (£7,000 or £8,000 each, I believe) are the measure of the value in which these monumental objects are still held. There are many fine examples in the galleries of the Louvre, in Windsor Castle, and in private hands in this country. In my next lecture I hope to show photographs of several. Other veneered furniture was made in abundance throughout the century in Italy, Germany, and in this country. There is one Italian artist, A. Pietro Pifetti, a Piedmontese, who worked in a similar way to Boulle. He used ivory, mother-of-pearl, coloured woods, and brass. He was only born in 1700, but I mention him here as his work is, in many

ways, allied to that of Boulle. His works are well known in Turin, but genuine pieces by his hand are rarely met with in this country.

Veneering in wood, known under the name of marquetry, had been made from before the 16th century in Italy; sometimes in one wood —pine—the grain of the wood being so set as to help the design, and a certain amount of shading added by means of hot iron. Some good panels of this kind can be seen in the large North Court of the Kensington Museum. Other kinds consist of architectural elevations and interiors, little figure compositions done in veneers of lime, pear, and other light-coloured woods, occasionally helped by artificial staining. They are common in the marquetry furniture of northern Italy of the 17th century. That sort of decoration became common in England after the Revolution, when Dutch workmen and Dutch furniture found their way into the country. Till that time the general decoration of our furniture was due to the carver, as it had been from immemorial custom. Down to the close of the century country houses maintained their old character, the palaces and public buildings of Jones and Wren notwithstanding. Massive staircases, solid furniture, decorative panelling, continued to be made. Every country town could furnish workmen competent to do the wood-work, and to prepare for the carving that might be required. The severer lines and proportions of Wren were more in fashion in London and amongst court personages than with the squires and landowners that made up the wealthy middle classes that were the backbone of the country.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

GROUP XIV.—APPARATUS, PROCESSES, AND APPLIANCES CONNECTED WITH APPLIED CHEMISTRY AND PHYSICS.

By Boverton Redwood, F.I.C., F.C.S.

(Continued from p. 969.)

Part II.

The production of paraffin oil by the destructive distillation of shale is a process allied to that of coal-gas manufacture, and at this point the exhibits relating to the shale oil industry may conveniently be described.

Young's Paraffin Light and Mineral Oil Company contribute a fine collection of specimens of mineral spirit, burning oils, lubricating oils, paraffin candles, sulphate of ammonia, as well as basic oils, phenols, and liquid paraffins of scientific interest. The high quality of the commercial products is largely due to the adoption by this company, under the direction of Mr. John Fyfe, Mr. McCutchon, and others, of improved plant and processes. Reserving for the present a description of the Young and Beilby retorts employed, reference may be made to the use by this company of the coke tower scrubber, in conjunction with arrangements for the better fractionation of the coke tower naphtha; and of the filter press for the separation of paraffin from the lubricating oil. The company's plant also includes improved machinery for the cooling of the oil containing paraffin, and for bringing the paraffin into a condition suitable for candle making. Young's Company are also manufacturers of mineral oil lamps on a large scale, and the exhibit includes specimens of several lamps of considerable merit. No better illustration of the benefits of competition could be desired than that which is furnished by the paraffin oil industry. Not many years after its foundation by Mr. James Young, in 1860, the manufacture of oil from shale was threatened with extinction, in consequence of the importation of American petroleum, and the present condition of that manufacture is, without doubt, largely due to the improvements necessarily effected during the struggle for existence.

The construction of the retorts already mentioned is shown by the model exhibited by the inventors, Mr. W. Young and Mr. G. Beilby. Prior to this invention the coke or residue from the distillation was discharged from the retort still containing about 50 per cent. of the total nitrogen of the original material. The invention consists in supplementing the process of distillation by burning the carbonaceous residue in steam, or a mixture of steam and air, whereby the carbon is oxidised to carbonic anhydride and carbonic oxide, the nitrogen being liberated as ammonia. The retorts are vertical, the upper part of iron, and the lower of fire-clay. The distillation of the oils takes place in the upper less-heated portion, and the other part of the process in the highly-heated lower portion. The residue is gradually raked out from the bottom of the retort, and fresh shale introduced at the top, so that the operation is continuous. Not only is the yield of ammonia very greatly increased (to the extent of 14 lbs. of sulphate of ammonia per ton of shale) but the yield of paraffin products is greater. Already seven companies, distilling collectively over 700,000 tons of shale per day, have taken licenses to use the invention. Messrs. Young and Beilby also show drawings of an apparatus for the continuous distillation of mineral oils. The apparatus consists of a long cylindrical boiler, partitioned so that the oil fed in at one end follows a tortuous course in reaching the opposite end. Each partitioned space is provided with a separate off-take pipe and condensers. As the

oil flows from space to space, it parts with its successively less volatile portions until it reaches the end space, from which it is removed as a thick residue. The invention embraces apparatus for the fractional condensation of oils, and for the distillation of the less volatile residues. The improved fractionating arrangements render the distillates more homogeneous, and therefore better adapted for the purposes for which they are used. Thus the burning oils, being more nearly of uniform boiling point, burn better; and the lubricating oils, being more free from low boiling point oils, have greater viscosity and higher flashing point.

From the consideration of exhibits relating to the production of paraffin, we may pass to those which illustrate the use of this product in candle making.

Price's Patent Candle Company have an excellent exhibit, organised by their manager, Mr. Calderwood, the improved candle making machinery, invented and constructed by the engineering staff of the company, being shown in practical operation. The moulding of spiral fluted candles, and the plaiting of the wicks, are among the operations which are viewed with considerable interest by visitors to the Exhibition. The specimens of soaps shown include solidified glycerine soap, made by Payne's process without the use of spirit, and containing 50 per cent. of pure glycerine. Among the other specimens exhibited are cloth oil, made by Rumble and Sears' process, which is stated to be less liable to oxidation, of greater viscosity, and more easily removed from the wool in the process of scouring, than is ordinary cloth oil; also fatty acids and glycerine made from palm oil, tallow and greases, by Rumble and Sears' process. In this process the fatty substance is mixed with the zinc or magnesium salt of a fatty acid, and the mixture is exposed, with water, to the action of high pressure steam in a closed vessel. The glycerine formed is separated in the usual way, the soap decomposed by a mineral acid, and the zinc or magnesium recovered. The fatty acids so obtained are of an improved colour, and are available for direct conversion into soap nearly equal in colour to the neutral fats operated on. The crude glycerine obtained is more readily and economically refined than that produced by the older methods.

Messrs. J. C. and J. Field have also an excellent exhibit of their well-known soaps and candles, including ozokerit candles of high melting point. This firm made candles from the Irish Peat Company's paraffin, under J. K. Field and Humphrey's Patent, as long ago as 1856, and have contributed very largely to improve the manufacture of candles of various kinds. The self-fitting end with which candles are now commonly made was patented by Mr. J. L. Field, and many patents for providing candles with vertical internal spaces, and for producing candles of ornamental appearance, have been taken out by members of the firm. Among the articles exhibited is the lychnophylax or candle guard, for the prevention of guttering.

The compound lubricating oils exhibited by Messrs. J. Veitch Wilson and Co. are of high quality. In these compound oils the fixed oil is of great viscosity, and is therefore capable of being associated with an unusually large proportion of mineral oil.

Among the exhibitors of manures are Messrs. E. Packard and Co., whose exhibit has already been referred to in dealing with those which relate to sugar manufacture. This firm manufactures a high quality of superphosphates, specially suitable for export in cases where the cost of transport is considerable.

Mr. H. B. Condy exhibits a new permanganate disinfectant, produced by adding potassium permanganate to a solution of aluminum sulphate, and separating the potash-alum by crystallisation; and Messrs. F. C. Calvert and Co. show specimens of coal-tar acids, and of a new disinfecting powder made by mixing carbolic acid with kieselguhr, the infusorial earth being capable of absorbing an equal weight of the coal-tar acids.

The exhibitors of paints include the Sankey White Lead Company, who show white lead made by Milner's process; Messrs. J. B. Freeman and Co., whose non-poisonous white lead consists of sulphate of lead ground with oxide of zinc and a small percentage of magnesia; Mr. Thomas Griffiths, whose substitute for white lead is sulphide of zinc; Messrs. Bolton and Partners, who exhibit strontia paints, colours, and glazes; Messrs. Aspinall, Aspinall and Co., who have a paint which is freely miscible with water, and yet which covers well, dries quickly, and furnishes a washable surface; and Messrs. Donald Macpherson and Co., whose quick-drying paint is specially adapted for coating railway signals. Browning's preservative solution, which has been applied to Cleopatra's needle, is shown by the Indestructible Paint Company; and a fire-proof paint by the Patent Liquid Fire-proof Cyanite Paint Company.

Among the miscellaneous exhibits of conspicuous merit is the large collection of seaweed products contributed by Mr. Edward C. C. Stanford, who is well known to have worked for many years, with the most praiseworthy perseverance, to replace the primitive and wasteful process of burning the weed into kelp by more scientific methods of obtaining the iodine and other products. The specimens include a complete set of products obtained by Stanford's process of carbonising seaweed, and a series illustrating his new wet process, whereby algin, cellulose, and kelp substitute are produced. In Stanford's original process, patented in 1862, the weed was carbonised in retorts, and the loss of one-half of the iodine—which takes place when the weed is burned in the ordinary way—prevented. This process was first carried out commercially in 1863, and in that year the writer saw it in practical use in the island of Tyree. The works then erected in Tyree and North Uist are still in operation, but the process not being of universal application, the following method of working has been devised by Mr. Stanford. The seaweed is first boiled with sodium carbonate, the

solution filtered and precipitated with sulphuric acid, the precipitate being the new substance, algin, which resembles albumen. The solution is neutralised with limestone, the calcium sulphate deposited, the neutral solution evaporated down, and the sodium sulphate crystallised out. The mother liquor, containing all the potassium salts, and iodine, forms the kelp substitute. The residue on the filter is the cellulose. Algin is proposed as a substitute for starch in the finishing of cotton fabrics; as a mordant for use in dyeing, &c. When dry, the algin resembles horn, and as it is turned and polished with facility, studs and buttons may be made from it. Shellac combines with sodium alginate and ammonium alginate, forming a soluble compound of great flexibility. Sheets of this compound, on being dipped into dilute acid or calcium chloride, are rendered insoluble, and form a tough membrane resembling gutta-percha. The material thus produced is a good electric insulator. The cellulose may be compressed into hard blocks, when it resembles ebony or bone.

The Eglinton Chemical Company exhibit specimens of chromates and of leather tanned with a chromate. This process of tanning is stated to be effected in one-fifth the time occupied by the ordinary process, and at less than half the cost. The leather is said to be more durable than ordinary leather, and to be thoroughly waterproof.

Mr. T. Nordenfelt sends a collection of oils, albumen, glue, &c., extracted from fish.

Preservative papers made by treating paper or other fabric with a coal-tar product, and passing the material thus prepared between heated rollers, whereby it is rendered fit to be handled, are shown by the Chemical Papers Company.

A model illustrating the principle of refrigeration adopted in the Bell-Coleman apparatus, now largely employed in connection with the importation of fresh meat, is exhibited by Mr. J. J. Coleman. The air discharged from the machines has usually a temperature of $-80°$ F., and is distributed in the meat chambers by pipes carried round the roof. It is stated that meat to the value of £5,000,000 is thus annually imported.

Dr. A. C. Burghardt exhibits an ingenious apparatus for the condensation of vapours. It consists of a number of sheets of wire gauze or perforated plates of copper, placed one above another, and so arranged that through one portion the vapour to be condensed passes, while through the other the cooling medium circulates. The sheets of wire gauze being partially in the cooling space and partially in the cooling medium, heat is rapidly conducted from the former to the latter, and very efficient condensation takes place.

Wrought iron and steel bottles for compressed gases, fitted with valves of simple construction that are gas-tight at great pressures, are shown by Mr. John Orchard. Bottles of similar construction formed part of the balloon equipment employed in the Soudan war.

The exhibits, in Group XV., of lamps for burning mineral oils are not numerous. The lamp shown by Messrs. J. Defries and Sons has a wick of circular transverse section, enclosed in a tube extending nearly to the bottom of the oil reservoir, the passage of flame to the contents of the reservoir being thus prevented. Air is supplied to the centre of the burner by a smaller tube passing through the bottom of the lamp, and terminating in an air-diffuser of novel form. The use of this lamp is free from the risks which the inquiry now being conducted by Sir Frederick Abel and the writer has shown to attach to the employment of some forms of mineral oil lamps, while the light afforded is of remarkable power in relation to the size of the burner and the quantity of oil consumed.

The "Sirius" burner, exhibited by the Patent Argand Gas and Oil Burners Company, is the invention of Messrs. Morrison and Smith. It is of the compound Argand type, having two concentric wicks, and has experimentally yielded excellent results. In consequence, however, of delay in carrying out certain details of construction, the lamp was not submitted to the Jury.

Messrs. Browne and Co. exhibit Messrs. James Hinks and Son's well-known "Duplex" burner, fitted with an ingenious arrangement to facilitate the lighting of the lamp by raising the globe and chimney. This firm also send the "Mitrailleuse" burner, which is furnished with a number of cylindrical wicks arranged in a circle.

The "Hesperus" burner, shown by Messrs. Jones and Willis, has three flat wicks placed triangularly.

A lamp in which heavy mineral oils can be satisfactorily burned is exhibited by Mr. Schandor in the Russian section, and various lamps for bicycles and tricycles by Mr. Salsbury in the carriage department. Good and cheap lamps of the Argand type are contributed by Messrs. Kynoch and Co., and useful little lamps for fitting into candlesticks by Mr. Sale.

The number of visitors to the Exhibition for the week ending Tuesday, 25th August, was 141,566. Total since the opening, 2,357,497.

CINCHONA IN BOLIVIA.

The United States Minister at La Paz, in his last report to the Government on the trades and industries of Bolivia, states that very large quantities of cinchona bark are annually exported from that country. Formerly the bark was gathered by the Indians, and in such manner that large forests were destroyed, the trees cut down, and the bark taken in any manner, merely to make up large quantities. At the present day, *quinales* plantations, as they are termed in Bolivia, are cultivated with care, and in a scientific

manner, the principal planters being Germans. This scientific cultivation of quina in plantations has now been carried on for about seven years, and the districts in which it is chiefly practised are Mapire, where 4,500,000 plants are cultivated; Longa, 500,000 plants; Yungas, 1,000,000; and Guanay, 500,000; making a total of 6,500,000 plants. Where the principal *quinales* are, it is a very rough and broken country, the Andes being cut and seamed into deep valleys in every direction. The trees are planted on the sides of the valleys or ridges, in altitudes of about 3,000 to 4,000 feet above the sea. They will grow higher up, even to 8,000 feet, but in that case they are stunted, and will give little or nothing of what is called quina salt. The plants require a great deal of sun, heavy rains, and fresh winds. A tree will yield from fifteen to twenty pounds of seed. The seed is collected in November and December, which in Bolivia are the early summer months, and are planted very thickly in boxes or beds, about twelve feet in length and three feet in breadth, and placed on a slight decline and well irrigated. When the plants are about six inches in height, and have a few leaves, they are transplanted; holes of from eight to ten inches deep are dug about six feet apart, in which they are placed. The plant is then covered partly over with twigs and other light stuff, grass and leaves, to keep off the sun for about three months. When the plant is strong and healthy, the undergrowth of other plants is cleaned out, great care being taken in conducting this operation. This attention to the plants continues for about two years, and then they are left and considered sound. About 25 per cent. of all the plants decay or rot before they come to maturity. When the tree is six years old, it is about fourteen feet in height, and has a diameter of about six inches up to six or seven feet. When the bark is of the most productive kind, the trunk grows straight and slender, and has the form of an orange tree. When a tree is left standing for ten or twelve years, it is over a foot in diameter, and the bark is thicker and heavier, but not so productive in quina. The bark is ready to cut when the tree is about six years old. A transverse incision is made in the trunk of the tree a few inches from the ground, another incision some twenty-four inches higher up and two vertical incisions opposite. The bark is pulled off in two pieces. Two cuts and sometimes three are made in each tree twenty-two or twenty-four inches long, and seven or eight inches wide. After the tree is stripped it is cut down, leaving a trunk about a foot above the ground, and from the base where the bark has been left there spring out about fifteen or twenty shoots or sprouts; these are left growing until they are a little higher than the stump, and are then thinned out, only two or three being left. The trees produce on an average about four to five pounds of bark, and the bark is placed in paved yards, and is generally cured in four days, but in rainy seasons it requires nearly three weeks. The United States Minister says, in conclusion, that as the greater part of the quina forests in Bolivia were destroyed, the cultivation has not until very recently been carried on in a systematic manner, and it is only within the last two or three years that it may be considered as forming one of the chief industries of the country.

PACIFIC FORESTS AND RAINFALL.

It appears, from the American Census Report, that the forests of the Pacific region owe their density and position to the character of the rainfall, which, upon the northern coast, is unequalled by that of any other part of the continet. This rainfall diminishes with the latitude, until, in Southern California, the temperature of the land so far exceeds that of the ocean that precipitation is impossible through the greater part of the year. The coast range and the Sierra catch most of the rain, and are well wooded, while the valleys are treeless. On this coast the general distribution and density of forests follow the distribution and amount of the rainfall. The forests of the Pacific region are, first, the Northern Forest, extending from the 70th to the 58th degree of latitude. The principal trees of this division are the white spruce, and the most important species of the North Atlantic region, the canoe birch and the balsam fir, are replaced by allied forms of the same genera. The Coast Forest, the heaviest, but not the most varied of the continent, extends in a narrow strip along the coast, from the 60th to the 50th parallel, where it widens and extends westward, and then follows the summits of the Sierra Nevada, almost to the Mexican border. This forest is composed of a few coniferous species. The absence of broad-leaved trees on the Pacific coast is striking, The most valuable woods of the Coast Forest are the Alaska cedar, the tideland spruce, the hemlock of the north, and the red fir. The Coast Forest of California is divided into three sections—the forest of the coast range, that of the western slope of the Sierra, and the open forest of the valleys. The important feature of the Coast Forest range is the red wood belt, whose heaviest growth is found north of the Bay of San Francisco. No other forest of similar extent equals, in amount of material, the groups of red wood along the California coast. The forest of the western slope of the Sierra is surpassed in density only by the red wood belt. Its characteristic species is the great sugar pine, and it is situated between 4,000 ft. and 8,000 ft. elevation. It extends from the base of Mount Shasta to the 35th parallel, ceasing near the boundary of Mexico. The forest of the valleys is composed of scattered oaks. East of the Sierra, and reaching to the Rocky Mountains, is the Interior Forest, whose trees are the least valuable of all.—*The Times.*

TRANSPORT AND ENSILAGE OF MULBERRY LEAVES.

During the silkworm rearing season in Northern Italy, a large quantity of mulberry leaves are sent by rail from one place to another, and in many cases the railway administration run special night trains for this purpose. The leaves are packed loosely in sacks, and often arrive at their destination far from fresh, and, consequently, if not totally unfit, at all events cannot afford a wholesome for food the nourishment of these insects. An experiment was made during the present season, by a silk producer in Lombardy, in sending the leaves compressed, and for this a bale was made, weighing 116 kilos., by placing the leaves between two round pieces of board (in this case the bottoms of barrels), and compressing them in an ordinary wine-press; the bale was then firmly secured with iron wire. By some oversight, this bale of compressed leaves made on the 23rd of May was not forwarded to Milan, and from thence to Niguarda, until the morning of the 31st, and consequently it did not arrive at its destination until later. On opening the bale, the leaves, with exception of about two inches in thickness round the outside, were found to be perfectly fresh and sweet, and even these were only faded, and found to be not unfit for food. This is a conclusive proof that the nutritive qualities of the leaves can be preserved for some time, if compressed, and the air thus excluded from them; care, however, must be taken not to crush them, and injure their tissues by excessive pressure. From that it would appear that a system of ensilage might be adopted with advantage for preserving mulberry leaves in the same way that it is for forage. Another advantage of such a plan would be that the leaves so compressed would be reduced in bulk, and consequently fewer trucks would be required to carry a given quantity of leaves than there is in the ordinary way; and by ensiling the leaves grown on the warmer side of the Appenines, as, for instance, on the "Riviera" of Genoa, &c., it would be possible to supply the silkworm rearers of Piedmont and Lombardy during backward seasons, or when, from other causes, the leaves are scarce and expensive.

Correspondence.

ON THE ACTION OF POLLEN IN THE PRODUCTION OF HAY FEVER.

In a recent number of the *Journal*, Dr. Poore, in one of his Cantor lectures, makes reference to my researches on the subject of hay fever, and gives me credit for opinions on the nature of the action of pollen which do not coincide with those I hold. In speaking of this, Dr. Poore says that I have "come to the conclusion that the action of pollen was partly chemical and partly mechanical, and that the full effect was not produced until the outer envelope (of the pollen grain) burst, and allowed of the escape of the granular contents." This is true to a certain extent, but it does not represent the exact state of the case; and so far as concerns some of the most troublesome symptoms of hay fever, gives but an imperfect idea of the extent and character of the action of the agent in question. It is quite true that I have stated that the mechanical action of pollen does probably give rise to one of the earliest symptoms of hay fever, and also that these may be partly due to the coating of wax or oleo-resin found on many pollen grains. In all I have written on the subject, however, I have, in one place or another, given due prominence to the physiological character of the action of the pollen, as the following quotation from the first edition of my work will show:—

"From the results obtained in the experiments described, I have come to the conclusion that the disturbance caused by pollen is due partly to its mechanical, and greatly to its physiological, action. From the circumstance, however, that the coating of wax or oleo-resin, of which I have spoken (§ 145), probably has some volatile oil combined with it, it is possible that this may commence the disturbance; but whether this is chemical or physiological in its character is not certain. The mechanical changes I have described would be quite sufficient to account for some of the earlier symptoms of hay fever, but some of the late phenomena will, no doubt, be due to the physiological action of the granular matter of pollen."

In the second edition of my work, published in 1880, I have spoken much to the same effect, but since that time I have been able to isolate the wax, or oleo-resin, alluded to above, and have found that it has no power to give rise to any of the symptoms of hay fever. I am the more desirous that the fact of the physiological action of the pollen should be clearly and definitely stated, because a considerable number of my medical brethren doubt the possibility of minute quantities of any substance not belonging to the zymotic class being capable of setting up this kind of action. There can, however, be no doubt that the derangement in hay fever is produced by the contact of exceedingly small quantities of the exciting cause. Carefully conducted experiments show that at the commencement of the disease, at the beginning of the flowering period of the grasses, so small a quantity as the 400,000th of a grain, inhaled during each hour of the day, gives rise to very distinct, and sometimes not pleasant, symptoms; whilst at the period of greatest intensity, at the height of the hay-season, the average quantity inhaled each hour does not exceed the 30,000th of a grain in weight.

It is a remarkable thing that so apparently innocent a substance as pollen should be capable of setting up so much disturbance in the organism of only a very small per-centage of the population, whilst the great

bulk of the people remain entirely unaffected by it. It is also, at first sight, equally remarkable that quantities so small as those named should have the power of deranging the healthy action of the mucous membranes, even of sensitive individuals. The facts I have given with regard to quantities, however, can be easily demonstrated by any one who is moderately versed in the use of the microscope, any summer during the time the grasses are in flower, if they are willing to pursue the experiments on the lines indicated in my work.

The disappointment felt by the correspondent who writes in the *Journal* of July 17th, would be to some extent justified if I had contented myself with merely investigating and determining the cause of hay fever. I have not merely done so, however, and thus, so far as I am concerned, there is no cause for the disappointment felt by the writer of the letter. At the commencement of my own attacks scarcely anything was known of the nature of the ailment and nothing whatever of its causes. It, at that time, seemed to me that, before anything satisfactory could be done in the way of treatment or prevention, its causes would have to be clearly made out if possible. Bostock, the first writer on hay fever, believed his attacks to be due to the heats of summer, and, before I began to make any experiments, I held, for some years, the same opinion. I determined, however, to investigate the matter as fully as my opportunities would permit, and being a sufferer from the malady, I was able to do this in a practical manner. The investigations were systematically commenced in 1859, but made very slow progress for a time. After some twelve years of steady work, however, I was able to say definitely what I believed to be the cause of hay fever in England, and in 1873 the first edition of my work was published.*

The questions of treatment and prevention still remained unsolved, and after a short interval, I again set to work to determine the right methods of treatment, and the best means of prevention, if this should be found to be possible. It would, I think, be out of place to attempt to give, in this *Journal*, any details of the means used for the accomplishment of the objects in view, and it must suffice to say here that they were quite successful. A full account of these is given in the second edition of my work, published in 1880.†

From the tone of Dr. Poore's remarks, and from the fact that he names only the first edition of my work, published twelve years ago, I imagine he is not acquainted with the latest investigations, and cannot, therefore, be blamed for not alluding to them. There are, however, some physicians who are fully acquainted with all I have written on the subject of hay fever, and who, whilst speaking in high terms of the scientific character of the researches, are careful, when lecturing or writing on the subject, to avoid speaking of the means used by me for the treatment and prevention of the malady.

CHARLES H. BLACKLEY, M.D.

Old Trafford, Manchester.

* "Experimental Researches on the Causes and Nature of *Catarrhus Æstivus* (Hay Fever or Hay Asthma)." London: Baillière, Tindall, and Cox, 1873.

† "Hay Fever: its Causes, Treatment, and Effective Prevention." London: Baillière, Tindall, and Cox, 1880.

General Notes.

SAFETY BRATTICE CLOTH.—Mr. Ellis Lever has offered a prize of £100 for the invention or discovery of a new method or composition for treating canvas or other material for use as brattice-cloth and air-tubing in the safe ventilation of coal mines, which shall, at a moderate cost, render such material air-proof, damp-proof, and fire-proof, and superior to any brattice-cloth and air-tubing at present in use. For further information as to the terms of the offer, application should be made direct to Mr. Ellis Lever, Colliery Offices, Bowdon, Cheshire.

IRON AND STEEL INSTITUTE.—The autumn meeting of the institute will be held in the Corporation Galleries, Glasgow, from the 1st to the 5th of September next. A list of the papers to be read has been issued, with information respecting the excursions. The Secretaries' Office will be open at the Corporation Galleries, Sauchiehall-street, on the afternoon of Monday, August 31, for the issue of programmes, members' cards, dinner tickets, &c. The General Secretary's present address is St. Enoch's Station Hotel, Glasgow.

DURABILITY OF WOODS.—In some tests made with small squares of various woods buried an inch in the ground, the following results, says the *Garden*, were noted:—Birch and aspen decayed in three years; willow and horse chestnut in four years; maple and red beech in five years; elm, ash, hornbeam, and Lombardy poplar in seven years; oak, Scotch fir, Weymouth pine, and silver fir decayed to a depth of half an inch in seven years; larch, juniper, and arbor-vitæ were uninjured at the expiration of the seven years.

ST. BERNARD TUNNEL.—A new trans-Alpine line, the St. Bernard Railway, is likely to be commenced before very long, and to be, when completed, a dangerous competitor for the through traffic with the existing route of St. Gothard. One of the principal features of the new project is that the indispensable tunnel under the Alps—at the Col Ferret—will be very much shorter than any other, either constructed or proposed to be constructed. The length will be only 9½ kilometres (5¾ miles), while the St. Gothard tunnel is 15 (9¼ miles), the Mont Cenis 12, and those under the Simplon and Mont Blanc 20 and 19 kilometres respectively. The total length of the St. Bernard line will be but 138 kilometres, or 86 miles, making a saving between London and Brindisi over the St. Gothard route of 59½ miles.—*Engineer.*

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

EXAMINATIONS, 1886.

The Programme for 1886 is now ready. Copies can be obtained gratis on application to the Secretary.

Proceedings of the Society.

CANTOR LECTURES.

CARVING AND FURNITURE.

By J. Hungerford Pollen.

Lecture IV.—Delivered March 30, 1885.

1. When you set about to furnish any man's house, the first question seems to me to be the owner himself. How is his own mind furnished? Everyone who orders a house for himself ought, in my judgment, to know his own mind, and so far as regards the house, his architect ought to know it too. He need not be learned in the matter, but one expects him to have some leanings towards this or that. He should have seen other houses, and some one amongst them should have left some definite impression on his mind. He has to show this to his architect. All he will show will be symptoms, as a patient details his symptoms to a doctor. It is for the architect to explain them to understand what his client wants. And as the owner of the house can only unfold his mind in generalities, it is for the architect to meet it in particulars. That is part of his profession. To be an architect one has to know, and know thoroughly, all the necessities, all the splendours, all the possible circumstances of ordinary life. I do not think that many architects are trusted to supply these various needs. Furnishing is left to advertising tradesmen. It is but common justice to bear witness how well many of our present firms do this part of their work. But they labour under a great disadvantage. They have to run a race against fashion, and fashion is under no sufficient rule. They try to outdo each other in novelties, it must be so; and their best performances are copies of the work of a century back. In this respect we show well. These copies are often admirable, I mean the solid mahogany chairs and tables, and the veneered furniture of mahogany, in all its varieties of pattern, of satin wood, and other rare material.

2. As this lecture will be chiefly devoted to furniture proper, I propose to examine the sources from which we derive our modern furniture revivals. Of Jones and Wren we have already spoken. They worked for a learned age. They replaced the burly spirited carved woodwork of the Elizabethan style with a more cold, but a more correct and scientific, following of the classical. It was a good deal taken from the prevailing fashions of France in Wren's time. The Stuart kings had intimate relations with the French Court, and if you examine the panellings, fire-places, doorways, and so forth, in the houses built in that country during the 17th century, you will recognise the likeness. The French king was fastidious and arbitrary. He set the fashions in his own country, and assumed that other countries would follow the example. To a great extent he succeeded. But the fashions now popular are copied from those of a less severe period. The art of every period reflects the manners and the sentiments of its own day. It is stern, or it is devout and poetic, or, again, luxurious and gay, because the artists are generally men of their time, and because it supplies the wants of its own generation.

Everyone knows how gay the art of the 18th century was in France, how changed from that of the 17th, how entirely devoid of elevation of sentiment and aim. But French fashions prevailed over the greater part of Europe. The Italians, with better feeling, purer taste, and an astonishing skill in every kind of art connected with splendid and sumptuous living, were no longer supreme as

they had been. Italian workmen found their way to every country. In France and in this country, in the brilliant court of Augustus of Saxony, in most of the smaller States of Germany, and in Russia, Italian workmen were employed, but in carrying out French, not Italian, fashions. A number of Italian names are found among the decorators of houses and furniture of this country down to the century in which we live.

3. We had, however, during the last century, in England, architects who both built houses and designed the fittings and furniture they considered proper for them. As their designs are still highly prized, it is worth while to say something about them. Sir William Chambers, the architect of the present Somerset-house, of private houses at Roehampton and other places near London, was a travelled man. He had been employed by foreign courts. He had made a voyage to China, and, as you know, had written a treatise on civil architecture and Chinese gardening. He is the first artist who seems to have appreciated the interesting side of Chinese art, known up to that time only as it is seen in porcelain. Chambers found a ready follower in Thomas Chippendale. If we examine the French carving of that day, which goes by the name of *rococo, rocaille coquaille*,—that is, rock and shell work—which surrounds the large wall mirrors, the large room panels and furniture, we shall find that the work of Chippendale for similar uses is both more interesting, and more massive and rich in artistic effect. Chippendale, following the same inspirations, made cabinets, bureaus, tables, and shelves of mahogany, with pierced galleries round them, to hold Indian, Dresden, and Chelsea porcelain, then and still so highly valued. These are distinct classes of work that, intended for the gilding, is full of salient portions and reliefs, so as to give the gilding all the value which is derived from the play of light upon its uneven surfaces. On the other hand, the mahogany furniture of Chippendale is as light as it is possible to make it without sacrificing the strength which each piece of furniture requires. It has proved in all cases to have been the very perfection of workmanship. We will examine some of it presently.

4. We occasionally meet with mahogany carved furniture, which is much more massive. I have not been able to procure photographic slides of good examples. There are old pieces in Wilton-house, the legs or supports, both of tables and chairs, are mahogany, bulging out and finely carved with acanthus work. These pieces are of older date than the designs of Chambers, but they belong to the time when mahogany was in general use, and are as massive as, but far superior to, the Dutch fashions of William and Mary in grace and decorative effect. The metal mounts and handles, in gilt bronze or brass, are generally of much richness, and all worked over with the tool after casting. I have also met with chairs with solid backs, on which are small panels carved out of the solid wood, containing monograms, sometimes Chinese devices in relief, but sunk below the surface so as in no way to interfere with the comfort of the sitter. The Chinese tastes of Sir W. Chambers introduced a kind of wood decoration, scarcely to be called carving, viz., fretwork and trellises. They are cut out with fine saws, or, if on a larger scale, are examples of open-back parqueting. Photographs of towns, houses, and gardens in China show us trellises or fretworks of this kind in endless varieties. They are rectangular compositions, and seem to be used as fences, or railings, or gallery balustrades. Though the openings are apparently all of one pattern, and are all of similar proportions, they are found often to vary in many subtle ways. Simple as these trellises are, they are of great value in furniture design, and are well worth studying. The ordinary key fret, single or double, belongs also to this class of decoration. It occurs in the finest wood-work of the Renaissance carvers, and in the mouldings and borders of Chambers, and indeed, is met with in antique decoration.

Amongst the furniture designs of the time of Chambers, we ought to notice the admirable ceiling decorations, of which such numerous examples are still to be seen in London and in country houses. Some are evidently the work of French or Italian designers. Cipriani, Capitsoldi, and Voyers are names of foreign workmen and artists whom Chambers introduced into, or attracted to, this country. Ceilings are to be met with, set out with fine mouldings after the fashion of some of Boulle's cabinet fronts; portions filled with trellis, the moulding decorated with offsets of natural foliage; panels filled by busts in relief; little figures sitting on the mouldings, designed after nature, representing the costumes of various nations, drinking cups of tea, or in fanciful attitudes. Work as excellent as this is rarely met with later than the middle of the century. Very good Italian ceilings are still to be seen in large houses in Dublin, built some thirty years before the Union.

5. Another name deserves special mention, especially in this place, that of the brothers Adam—the two *Adelphi*—who have left their name to the streets immediately round us. They acquired the ground in 1769. Robert and James were speculators; fortunately, they were also accomplished architects. Lansdowne-house, Berkeley-square; Derby-house, Grosvenor-square; the houses in Portland-place, and numbers of other buildings were built by the Adams. They designed their ceilings, wall decorations, and the entire furniture of their houses. Their architecture is less bold than that of Chambers and his school. Their decoration is thin, their mouldings small; they lack a good deal of the play and inventiveness of an earlier day. But they followed carefully the decorative work they had studied on the architraves and cornices of the Roman ruins. Their most important drawings have been published, and numbers of original designs are to be seen in Sir John Soane's Museum, Lincoln's-inn-fields. It should be remembered that Herculaneum and Pompeii were then new discoveries, and public interest once more turned eagerly to classic models. The great men who had, in fact, produced a classic Renaissance, founded on such remains as were then known, did in fact create, with astounding skill and fecundity, a classical style of their own; but these men had long disappeared. Travelled artists had been to Greece as well as to Rome, and the revival of the days of the Adams was a new one, though of far less promise than that of the 16th century. The fine metal work recovered from Pompeii influenced the Adams, and suggested their thin swags, their wiry metal stars, fans, medallions, and other ornamentation. They did their best to introduce the figure into their decoration; medallions containing Hebes, cupbearers, and other single figures, drawn more or less from wall frescoes, figure constantly in Adam decoration. The execution of these portions we owe probably to the Italian modellers then working in London.

6. French furniture and carving underwent a remarkable change during the same period. Louis XVI. gave a name to much furniture of great beauty, and to an excellent style of carving. Old Paris houses, and old country houses in France, contain overdoor and chimney-piece panels, with classic vases, surrounded by foliage and fruit, gracefully composed, and carved with great skill. The style of this work corresponds with that of Grinling Gibbons. There is a little room of the time, now in the South Kensington Museum, the panelling carved with low relief, and gilded and painted, which is worth careful study. Most of the carving I have described, whether in oak or other woods, was intended to be painted. There is excellent French carving to be met with on small furniture, boxes, the frames of looking-glasses and pictures, of the same date. It was the fashion in French houses to insert paintings in oil in panels above doors and fire-places. Some are white, in imitation of reliefs of marble; others were filled by the canvases of Bouchet, Fragonard, and the school which they represent.

7. Carving, however, was on the wane during the years that preceded the French Revolution. Boule work replaced the noble and spirited carvings of Bachelier and a score of sculptors in wood. To Boule succeeded a number of makers of marquetry, or pictorial veneering, in coloured woods. But we have now to note an excellent kind of metal work, which made the chief decoration of the Louis Seize furniture. This metal work consisted of mounts or decorative edgings, lock-plates, borders, and so on, applied to veneered furniture, or to furniture made up with panels of Chinese lac work, or with panels of Sèvres porcelain, or porcelain cameoes made by our own Wedgwood. The artist best known in this kind of metal work is Gouthière. His mounts sometimes are little Cupids, or grotesque figures, with graceful foliage carefully modelled from nature. The work is cast in bronze, carefully chased, and well and thickly gilt. We shall see photographs of pieces from his hand presently. There were good mount workers in this country during the same period. Capitsoldi, already mentioned, was one of them. There was a taste for lac work in England during those years. Clock cases and other furniture are sometimes met with, bearing imitations in lac work and gold dust of Chinese designs. But the best contemporary lac work we meet with is imported from China, mounted in gilt metal, sometimes with silver lac. The days of Louis XVI. and of George III. were prolific in marquetery. A number of makers' names are preserved in Paris. Riesener and David are the two best known. Their work is sold at fabulous prices at the present day. Riesener's is generally laid out on a ground of tulip or purple wood, and in patterns of lime, pear, and other light woods delicately varied. Heads are sometimes introduced, and the attributes of geography or music, or some other scientific

subject. In those cases a very slight shading is introduced by burning, and the burning is effected by means of hot sand. A slight warm burnt umber tint is thus added where required, without the violence of colour produced by using red-hot iron. The best works of Riesener are veneered with light wood of various tints of leather colour. Those of David have woods of several colours, green ebony and stained woods. All this furniture owed much to the elegance of the metal edgings, mounts, and handles with which it was finished. In England very beautiful marquetry was made during the reign of the Adams in satin wood, which is of a delicate golden yellow, and with patterns and designs of mahogany and coloured woods. Some pieces of this kind—cabinets or sets of shelves in various quaint shapes, and surmounted by a clock or a stand for a piece of china—are occasionally met with. They are lined with tulip wood, or similar material, and are masterpieces of workmanship.

8. It is necessary here to allude to the polishing of furniture of this kind. Varnish with the brush is an odious way of defacing good, and of slurring over bad, work. The material is lumpy and uneven, and it attracts false lights, and indeed gives a general impression of unreality to the work it covers. But the polish known as French polish is first met with in furniture, carriage panels, snuff-boxes, and small objects under the name of Vernis Martin—Martin's polish. Robert Martin was a carriage painter, *vernisseur du roi*, born in 1706, and well known during the first half of that century. He painted heraldry, small subjects of Cupids and shepherdesses—probably employing many miniature painters. We find ivory fans with court balls and other subjects on them, and evidently by many hands. But his *vernis* was a fine lac polish, borrowed, probably, from the lac workers of China or Japan. It was laid on with great care, rubbed down, and laid on again till it reached the fine glossy surface of Japanese lacquer. It was considered a secret in his own day. The chief secret consisted in the careful manipulation, and the amount of what is familiarly called elbow grease applied to it. After his death this decoration was continued by his sons and others. In this country we see it applied to satinwood furniture decorated by the paintings of Cipriani, of the beautiful Angelica Kauffmann, and of other artists. This kind of polish is a necessary detail of veneering which must be absolutely secured from damp, so that the glue which holds it to its base may not run the risk of softening or disintegration.

9. How are we to offer any opinion on the funiture and the general art of woodwork of our own day? Perhaps by what we have seen in great Exhibitions. It is thirty-four years since these international shows began. I have had to form a judgment on contemporary furniture as far as it was illustrated in most of them. It cannot be doubtful that, between 1851 and 1884, there has been an enormous advance in this kind of sumptuary art. Carved sideboards and other important pieces of furniture sent to the earlier Exhibitions, and objects of great curiosity in their day, would compare very unfavourably with what has been seen on later occasions. There is, in the Kensington collection, a cabinet of carved pear-wood and ebony, with box-wood panels and terminal figures of support, from the Paris Exhibition of 1867, worth careful study. It has been removed from South Kensington to Bethnal-green. It is the work of Henri Fourdinois, and shows the fruits of careful instruction. The prominence of the greater features of support, the flatness of the panel reliefs, the repose of the finer cuttings on the mouldings, show how thoroughly the artist who designed and laid out the general plan has understood his work. The actual sculpture is excellent. But it is on this initial understanding that I want to insist. I remember, also, a small room, fitted round with panels and carving, I think by Messrs. Trollope, in Paris, in 1878; some admirable satinwood veneered work, by Wright and Mansfield, 1867; ebony and ivory marquetry, by Messrs. Jackson and Graham, in 1867. Carvings, sent by Vespignani, from Rome, in 1862; by Frullini, Giusti, and others, from Florence, in 1878, are full of grace, and bear testimony to the subtlety of feeling and the pliability of hand still proper to the Italian carver. As for Signor Bulletti, for some time head of the School of Wood-carving at Kensington, his work can be seen at Alnwick Castle. It is to be regretted that that building is not close at hand, that we might study it. Mark Rogers is a name too well known to need words of praise from me.

10. In treating of wood manufactures and furniture, I have dwelt all along on what I think a great need in England—a knowledge of the rules and outlines which govern good composition, and which are indispensable to the due value and effectiveness of ingenuity and skill of hand. Rules will not give us

inspiration, nor put grace and beauty into our creations. What they will do is to teach us how to bestow the skill of our carvers (which, observe, I take for granted) to advantage, and how to economise time and labour. To have the leading features of great pieces of carved work—the divisions, prominences, hollows—all in due proportion, and all in their proper places, is the first essential element of good composition. The filling up may be faulty, weak, wanting in knowledge and skill, but a certain grandeur and completeness will never be altogether wanting to a building, a picture, or a cabinet, if these outlines are well laid out at the beginning.

11. As regards furniture, under which term I include not only chairs, tables, cabinets, drawers, &c., but the entire interior architecture and disposition of halls and rooms: As regards furniture, we labour under the serious disadvantage of having no *style* belonging to our time or our country. Forty years ago, mediæval architecture seemed likely to be revived, both here and in many parts of the Continent. The Houses of Parliament, the chapels and halls of our ancient colleges, were either new structures or were restored and repaired. Great exertions were made to get casts and fragments of old work, from which carvers and joiners could work. Now, when we have succeeded in training carvers in one style, fashion has set towards another. Much knowledge of drawing is required for the carving of the present day, and constant study of old models. The old examples, indeed, are so very many, that their very number constitutes a serious difficulty.

12. Before closing these remarks, I must call attention to a kind of art very different from that to which our eyes have been used in the western world; I mean the wood-carving of the East. I have had opportunities of studying Oriental art, as we find it in the appliances of daily life, both in Syria, Egypt—that is, the art of various Arab races—and in India. You see Oriental art—for I class these phases of it under one head—you see that art in its most sumptuous form in India; in its greatest refinement, I believe, in Persia. But Persian art I know only from fragments in museums. I presume that the Indian Mahometans, the Syrians, Arabians and Turks, have derived their sumptuary arts from Persia; the Hindoos have derived theirs from northern Asia. As to Arab and Syrian art, there are examples of doors, door panelling, decorative panelling from mosques in Cairo, window screens, and an entire room, which can be studied in the Kensington Museum. There is a family likeness in the general arrangement of rooms in most of these countries; and the window screens, composed of trellises of turned wood, belong to a state of society in which the ladies of the family are kept in strict seclusion. In India you see these screens made of pierced slabs of marble in a variety of patterns—quatrefoils, circles, squares, and so on. They keep out the sun and admit the air, and the openings that are covered with these screens have the character of wall panels, richly wrought, full of repose, yet never dull in character. The light and shade which these admit inside the walls are as varied and agreeable as the chequered and subdued sunlight that reaches us through trees and flowers in the open air.

How far Oriental furniture carving and wood-work are admissable into modern houses is an interesting question; chiefly, as it seems to me, in such places as require screens or ventilators, and in the sides and backs of divans, benches, garden seats, and the like. As for the small Japanese window blinds sold in London, they are miracles of good workmanship, and perfectly calculated for the places they occupy. In India, broad verandahs or galleries round one side of the house are necessities. We see them frequently in Italy, as, *e.g.*, the famous *loggie* or open galleries round one side the Vatican palace and the Farnesina. In our climate the sun is rarely oppressive, and screens to exclude the sun and admit the air are not so much in request. Still, screens are required in many places; and turned or pierced work, easily executed, though it has not much design, is susceptible of endless varieties of pattern.

13. Amidst materials so numerous of such different kinds, what shall the student, the carver, the joiner, or the architect do? Since we are surrounded by splendid relics of the past and are not inventors, nor bound by recognised rules, we must try to get the past mapped out in our minds. The great variety of chests, cabinets, panels, and so on, that we meet with in museums, are all found, when studied, to have been made under definite traditions. Moreover, various as the work of different dates, and the inventions of different minds appear at first sight to be, this work has more in common than it has of what is distinctive, though it is also true that every inventive mind has its own character, and no two such

minds are absolutely alike. But it is the general obedience to laws which they all hold in common, and all take for granted, which leaves them otherwise free to use their imagination within these acknowledged limits with an inexhaustible fertility of invention. As for composing and carving, let no one suppose that he will ever master universal knowledge or skill. A designer, a carver, a workman will develop some one talent. He may have a natural aptitude for proportion, or for designing and carving graceful foliage, while the figure is up-hill work to him. Another will do that admirably, while his acanthus leaves will be arranged merely according to book without grace or feeling. Each must do his best with such gifts of hand and eye as he has. But though it is good to study all sorts of art, Italian, French, English, the Mediæval, Renaissance, Elizabethan, and Oriental, as well as western, and on the whole to master the ideas that underlie these varieties of art; though it is good to study this wide field, such an extensive study can only be for those that can find time for it. All such study is a gain, but to practice all these various kinds of carving is an impossibility. It is for the working artist to master the rules, the ideas, and the good examples of that branch of the sumptuary arts to which his mind and his hand turn naturally. It is *good* not to be ignorant of the ground that lies outside and beyond the field of your chosen labours, but it is *necessary* to know and be familiar with all that lies within it. To be *great* one must be *thorough*, and to master one kind of artistic excellence you must narrow your field of study. There is no kind of genius that is universal.

14. The retrospect one takes of the art of wood sculpture, and of that of furnishing rooms and houses, seems to show that sculpture—that is, wood-carving decoration in actual tangible relief—has in all times been considered the best kind of decoration. The best artists of the best times have decorated walls and houses with tangible and durable ornamentation. There is a feeling of completeness, of habitableness, even a sort of companionship in what is produced not by the illusion of painting, or by mere splendour of precious material, but by the constant play of light over actual relief on the work of the sculptor. In proportion as his dramatic power has dwindled, veneerings and surface colours have, in most countries, taken the place of solid reliefs. As to the skill, beauty, and refinement of such furniture as that of Boule, Riesener, Gouthière, and other marquetry makers, I have already said how highly I appreciate them. But these artists were giants in their way, and their work, though durable when well cared for, is much more liable to ruin than carved decoration; nor do the broken pieces and fragments of it give us the satisfaction we reap from panels, brackets, chest-fronts, and other relics of times of good carving.

I have expressed my regret that carving in such large and costly buildings as War-offices, Foreign-offices, Admiralties, and other national monuments of the architecture of our day, should not commemorate our skill as carvers in wood. If we economised some of the thirty or forty coats of oil paint which the walls of our public offices will receive during their first five-and-twenty years, and invested the money in carved mouldings, door-heads, chimney-pieces, and panelling, would the Treasury be a loser?

I do entertain some hopes of the architects of what is called the Queen Anne style. I hope they will get ashamed of putty squeezes and fanciful joinery, of which one sees a great deal too much, and take to honest carving, however the small the quantity, instead.

I have insisted on mouldings — carved mouldings—not to the exclusion of carved panels, door pediments, and porches, because many kinds of designs can be applied to them, and because lines—straight lines—have a sort of initial or fundamental value in decoration. The front of a house, the side of a room, are marked out by straight lines into their necessary proportions. These lines may be mouldings, string courses, or great masses like pilasters or columns. Doors, windows, and other openings we draw with straight lines. If we wish to enrich even a drawing, the artist draws one or two lines round the openings, to soften their edges. In actual doors and windows, fire-places and the like, mouldings of various sizes and sectional shape, are the lines by which we surround and soften off the edges of openings which would be bald, harsh, and dull if left bare. Such borders are real enrichments of the most legitimate kind, being tangible features of our architecture. Mouldings, moreover, are simple in the carvings they require, they may be decorated by hands that are but moderately skilled, and no other carving produces so broad and general effect in proportion to the labour and cost expended on its execution.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

BICYCLES AND TRICYCLES.

By C. V. Boys.

The exhibition of bicycles and tricycles, though by no means so large as the cycling public have been in the habit of seeing in previous years at the Stanley Show, and at the Sportsman's Exhibition in London, and at others in the country, nevertheless fairly represents the new and enormously developed cycle industry. This year, for the first time, the leading firms agreed no longer to support the two metropolitan annual exhibitions to which the public had flocked in order to see the latest improvements and inventions connected with cycling; whatever other reasons there may have been, it is probable that the superior advantages offered by the Inventions Exhibition over those which had been obtained, or which indeed, were possible on any previous occasion, must have weighed with the manufacturers in coming to this decision. It is therefore to be regretted that more space could not have been allowed, so that each firm could have shown one sample of each distinct pattern made. Several exhibitors complain that for want of space they can only show a part of a machine, or a convertible machine in its single form, or that some pattern which they make is necessarily excluded altogether. It is a satisfactory show in this respect, that, with very few exceptions, every machine which is known to be of a high class may be seen, while the eye is not distracted, as has been so often the case previously, by rows of a dozen or more identical machines, which tend to convert what should be an exhibition into a mere show-room or shop. There are a number of machines which merely show some peculiarity of detail which may or may not be an advantage, but which, at any rate, is, or is supposed to be, a novelty. There is a large proportion of exhibits which anyone with any experience as a cyclist and a mechanic must condemn at once as being useless, ridiculous, or even harmful. In fact, the proportion of such monstrosities is much greater than would have been expected where space is so inadequate. In one respect, this department of the Inventions Exhibition is quite peculiar, there are a few in which the special art has grown enormously in the last 23 years, *i.e*, since 1862, but this is the only one which has actually come into existence in that time.

The ordinary bicycle is now made by every firm on practically the same lines, and so it does not attract so much attention as the tricycle, nor does it afford so much scope for ingenuity. Though eleven firms show bicycles of the ordinary pattern, there are few special points worth noticing. Perhaps the most valuable of recent improvements in the bicycle, applicable to other machines in which there is a head, is the ball-bearing head shown by J. R. Trigwell (823). Saint George's Engineering Company show bicycles with highly laced wheels, as stiff and strong as it is possible to imagine. The Surrey Machinists Company's (814) invincible bicycles, like the tricycles of the same firm, have the very thin spokes and large hollow rims and tyres, which make these machines appear clumsy to the uninitiated, whereas they are, in reality, the reverse. The Coventry Machinists Company (807) show on their bicycles a most ingenious and excellent arrangement for making the cranks detachable, a special tool—reminding one of the automatic corkscrews—being supplied to pull the crank from the axle. The Howe Machine Company (804) show a bicycle with a spring in the head which at present can hardly be considered perfect.

The so-called safety bicycles—*i.e.*, machines making one track—in which the pedals are connected with the driving-wheels by levers or chains, are shown by nineteen exhibitors. That which most deserves the name of safety, though it is most like the ordinary bicycle, is the "Extraordinary," shown by Singer (808). This, though the first safety bicycle made, still retains its popularity. The next machine to become known was the "Facile," shown by Ellis and Co. (801). This soon gained a wide reputation owing to several extraordinary performances that were made upon it, and it is still very popular. In each of these, levers connect the pedals with cranks on the axle of the driving-wheel. Last year, Messrs. Hillman, Herbert, and Cooper (806) brought out a dwarf bicycle driven by a chain, the "Kangaroo," which can be geared up to any desired extent. This machine made so great a reputation in a race on the road, that it is now copied more extensively than any other make of machine, including the Humber tricycle. Nothwithstanding this, so perfect is the design of the "Kangaroo," that no improvements of any real importance have been made. Though to Messrs. Hillman, Herbert, and Cooper is undoubtedly due the credit of perfecting this class of machine, it was described for the first time, as far as the writer is aware, in the specification of a now lapsed patent of Otto about seven years ago. The Metropolitan Machinist Company (798) exhibit, under the name of the "Mazeppa," a safety bicycle which is identical with the safety of the Howe Machine Company, not only in build, but in the finish of every screw, and the rounding of every corner. The only difference that can be discovered lies in the name-plate, for whereas the latter firm have their name-plate in the usual place on the back bone, the former have none, but only two pins by which a name plate might be fixed. The most noteworthy deviation from the original pattern is to be found in the dwarf safety of Singer. This is best described as a cross between Singer's Extraordinary and the Kangaroo, for the raked forks

and sloping head of the former and the geared-up small wheel of the latter are combined. The Royal Machine Manufacturing Company (810) mount the bearings of the front wheel in an eccentric support, which gives the adjustment for tightening the chain. Messrs. Kelsey and Kelsey (783) and Trigwell replace the long bearing of the cranks with overhanging pulley wheel by a double bearing, with the object of making what is certainly the weakest part in machines of the Kangaroo type a little stronger. Trigwell, of course, applies his ball-bearing head to his Safety. Goy (837) and Phillips (843) show bicycles with two-speed gear attached. More will be said about such gears when tricycles, to which alone they can with advantage be adapted, are described. Meanwhile, the machine shown by Phillips serves to show how the introduction of a would-be improvement can do away with the chief advantage of a good machine; for here, not only has a Facile bicycle, a machine with a narrower tread than any other, by the addition of this gear, lost its simplicity and compactness, but its tread is widened to such an extent as to spoil the machine. No one has succeeded in improving a bicycle by adding to it a two-speed gear; nor is there yet any prospect that such an improvement will ever be made. There is another type of geared-up one-track Safety bicycle more recent than the Kangaroo. It has been rather aptly described as the kind of bicycle in which the large wheel is the small one, and the hind wheel is in front; but what is meant is, that the small steering wheel is in front, while the larger but still small driving-wheel is behind. The advantages obtained by this form of machine are considerable. In the first place, there can be a single crank axle, of which the bearings are not subject to such an enormous stress as is the case in machines of the Kangaroo class, while the rider being placed as much over his pedals as he pleases, and being still carried mainly by the driving wheel, is yet so far behind the front wheel that a fall over the handles is impossible, and so enormous brake power can safely be employed. The Birmingham Small Arms Company (794) exhibit an elegant machine of this class. Humber and Co. (849) exhibit a machine of the same class, but different in one important respect, the fork of the steering wheel slopes back at a steep angle, and its prolongation passing straight on through a kind of head, carries directly the steering handle. The structure of this part is the same as is employed in the well known front steering Humber tricycle, or "cripper" as it is often called. When the steering handle is deflected to either side, the frame of the machine which rests on a spring is slightly raised by the action of a cam below, whereby the natural tendency of the wheel is to set itself to a straight course, or it may be made to naturally travel in a circle of any radius according to the setting of the cam, hence the name automatic steerer.

There is one other kind of safety bicycle shown, the two-track machine, named after its inventor, the Otto, a machine which retains its popularity among those who can ride it. This is shown by the Otto Company (809). There is nothing peculiar about the machine exhibited, except the elastic spokes. Each spoke is made slightly wavy, so that most of the vibration from the road is lost in the wheel before the hub is reached, therefore the machine being less subject to jar as it travels, requires less force to drive it on a rough road. It was not believed that such a wheel would hold together any length of time, and the writer was strongly of that opinion, but having ridden a pair over 3,200 miles he has now satisfied himself on this point. He believes this to be the boldest and one of the most important improvements in suspension wheels that has been made.

Of tricycles many patterns are shown. Taking the front steering tricycles first as being the sort that with least skill can be ridden with greatest safety, there are of course well known machines, like the Premier and the Imperial Club, about which it is unnecessary to make any remark. It is only those which have any great peculiarity (not necessarily an advantage or the reverse) which need be pointed out. Maynard, Harris and Co. (776) exhibit the Devon tricycle, a machine in which the swing frame of the Otto has been applied, but with a locking contrivance so that the rider can fix himself in the most advantageous position, a matter of great importance in a hilly district. T. Moore (799) shows his orbicycle, one of the first machines in which a two-speed gear was used. Here the rider pedals forwards for speed and backwards for power, an arrangement which puts the rider more over his work when necessary. The bevel wheel driving gear is not to be recommended, and so a chain is to be used instead. Certainly the most remarkable front steering machine for novelty is that shown by H. Tandy (845). In the first place the frame is made of thin elastic steel instead of rigid tube. The frame is carried through the centre of the steering wheel which is actuated in a manner which cannot be readily described. Then there is a ten-speed gear driving pulley, very ingenious, but of doubtful utility. D. Weston (824) exhibits the original central geared front steering tricycle, a machine which was seen some years ago, but not taken much notice of. However he has now the satisfaction of seeing his design followed more or less closely by nearly every maker. There is a machine which is well worthy of notice, the "Grosvenor" tricycle, exhibited by Hart, Son, Peard and Co. (811). This is a single driving front steering machine with many good points. It is most unfortunate that what appears such excellent work, that such perfection in many details, should be thrown away on a design which is essentially faulty. A narrow single driver without the length of steering base, which alone makes the "Coventry Rotary" machine practicable, cannot by any possibility compare with a properly designed double driver. The steering gear is the neatest made, being entirely within the frame of the machine; it is possible by this construction to "gear the steering up or down," *i.e.*,

to make it more or less sensitive as may be desired. The means of changing the single machine to a sociable are certainly the best shown in the Exhibition, but again the double machine must suffer even more than the single from the fault in principle. The crank shaft is made in three pieces bolted together, which allows of adjustable ball pedals being applied. There is again one serious fault of design here, an overhang of four inches from the crank bearing to the crank pulley. The Surrey Machinist Co. exhibit their light invincible tricycle already referred to. There is another type of front steering tricycle introduced by Humber, Marriot, and Cooper, already referred to as the cripper. It is now shown by Humber and Co., by Marriot and Cooper (788), and in a modified form by Gibbons (780).

It is a good sign that there are hardly any rear-steering machines exhibited at all. The objections to machines of this type may be found in this *Journal* of May 9, 1884. The National Cycle Works (812) exhibit the direct action "National," about which the less said the better. Only two other rear steerers are shown, each of the "Rover" pattern, but with peculiar driving mechanism. Rudge and Co. (790) show a few Coventry rotaries, machines which are single drivers, but both front and rear steerers, and two track. On one are attachments certainly very neat for carrying a camera and the necessary adjuncts.

The fastest, and in skilful hands perhaps the best form of tricycle, is certainly the Humber, introduced by Humber, but now copied more or less faithfully by almost every firm. This type of machine can of course be best seen at the stall of Humber and Co., under the name of the "Genuine Humber." Though eleven firms exhibit machines of this type, hardly any show any points of novelty. W. Baden Powell (805) shows the "Cruiser" tricycle, a machine in which there is no handle bar, so that though there is not an open front, it is yet possible to get out in front in case of emergency. This machine has the further advantage that it can, in a very short time, be taken to pieces and stowed away in a small space. Stassen shows a telescopic machine of this type. H. Smith (830) shows a cheap machine with a larger hind wheel and wider base than usual, in which, owing to the rake of the head, the tail leans over in going round a curve.

Of tandem machines, the Humber pattern is shown by Humber and Co., by Marriot and Cooper; and telescopic by Stassen. This pattern has the reputation of being the fastest combination on three wheels made, but of course it requires skilful management. Perhaps the most useful of all is the Club tandem, shown by the Coventry Machinist Co. This is a combination of a front steering and a Humber pattern machine, in which the front rider controls the steering; but it will convert into either a front steerer (Imperial club) or into a Humber pattern machine (Sandringham club), so the owner of this combination has, in reality, three types of tricycle. H. Pausey (813) exhibit a very light convertible front-steering machine, with very small wheels. Rudge and Co. show their well-known Coventry rotary tandem. Here the faults of a single driver are far more pronounced than in the single form.

Carrier tricycles, introduced by Singer and Co., have been found so useful to tradesmen that a few other firms are now making them. By far the most delightful of all these is the Coventry chair, exhibited by Starley and Sutton (827). Instead of a box for parcels, a comfortable basket, like a bath chair, is carried over the frame of the machine, and low down. The driver is behind. The machine is a front-steering double driver, geared low, and with a strong brake. With such a machine, an invalid may enjoy a run of twenty miles in the country, at from six to eight miles an hour, instead of being laboriously dragged along at from two to three miles an hour, with by no means a pleasant view in front. Singer, Pansey, Hudson (831), and Brookes (797), exhibit carrier tricycles, either front or rear steering. The Coventry Machinist Company (750) show a carrier tricycle of the Humber pattern. However good this type of machine may be to ride, it is doubtful whether it is desirable to make a carrier of this pattern, for the machine, as is well known, is difficult to manage, and requires a skilful rider; while a carrier machine, which may have to be taken out by almost anybody, should certainly require the minimum of skill.

There are two machines which forcibly remind one of those strange freaks of nature which, like upland geese, seem to avoid their natural haunts. They are the "Oarsman" tricycle, shown by Taylor and Wethered (326), and the "Remicycle," by Thomson, machines in which the rider rows, not on the water, but on land. Another machine worked by the arms is the "Velociman," by Singer. Owing to the weakness of the arms compared with the legs, this kind of driving has not much to recommend it, except in those cases where, from injury or deformity, the rider cannot propel himself in the usual manner. The "Oarsman," however, has this further advantage, that most of the work is done by the muscles of the body and the legs, for the stroke is made by the pressure of the shoulders against the back of a rocking or sliding seat, and the arms are only used to finish the stroke. If these correspond with the freaks of nature, then surely the land and water machine, shown by Hollins (791), is the ornithorynchus among cycles. A model only is shown, but if the exhibitor would bring a real machine, and ride it round in the water during the illumination of the fountains, he would make the most popular part of the whole Exhibition even more entertaining.

One of the most beautiful exhibits is the crypto-dynamic gearing, invented by W. T. Shaw, and shown by the Crypto-Cycle Works (802). The inventor has probably done more than all the makers put together in perfecting a two-speed gear applicable to almost every tricycle, and in educating the public to understand its advantages. The work shown is of the very highest excellence. It is, unfortunately, the

case that the trade resisted the demand for this gear for some time, and then finding that a large proportion of the public would have something of the kind, they in many cases themselves tried to provide them, and possibly a few other good two-speed gears have been so designed. However the crypto gear has now earned a wide and well earned reputation. At first the gear was fitted at the end of the crank shaft, but now it and the balance gear are combined in one box, placed of course on the main axle. Rudge shows a two-speed gear, but not applied to a machine.

One of the most admirable differential gears is the Sparkbrook gear, invented by Hillman, Herbert, and Cooper. A visitor looking at this, and trying to understand how it worked, would be sure to fail, but to anyone who bears in mind the test of a true differential gear, viz., that if the chain pulley is held still, and one wheel is turned round, the other will turn at an equal speed in the opposite direction, it is the most obvious and simple of all. The Surrey Machinist Co. show a differential gear which is curious, but in which the teeth cannot work properly together. Singer still uses his unevenly balanced gear. The differential gear shown by Usher (841), as shown, is not likely to attract any attention, but if properly made, it would be the best gear in the show. An explanation of the difference between it and others, and wherein lie its advantages, would occupy too much space, but those who are interested in differential gears will find something worth looking at. The middle wheel should have exactly half the number of teeth of the outer wheel; in the one shown there are two more. Starley's gear, of course, is used on most of the machines.

In riding up hill on the ordinary make of machine, the rider fails in getting the feet over the dead points. If only he could in some way propel the machine a little at this point, he should be able to climb a steeper hill. In a few machines shown this can be done. First there is the "Merlin," which, like the Omnicycle, has no dead points, for the power is applied tangentially to a drum on the driving axle. Speed and Wills (821) show a machine with a long crank and a short connecting rod which gives a quick return motion to the pedal, so that by the time one pedal is at the bottom of the tread the other has already passed the top and is descending, and so there is no point at which the rider has not some propelling power. Markham (782) shows another contrivance to give a quick return. The dead point is overcome in an entirely different manner in the Otto, for here, owing to the natural swing of the frame, which is made more pronounced when much work has to be done, the upper treadle comes into an effective position as soon as the lower foot has finished its tread, even though the machine is at rest at this point.

There is one mechanical riddle which perhaps someone will solve, it is a screw gear shown by Settle (816). There are several sundries and appliances which would occupy too much space to describe, but Dearlove's Thresher link (822) deserves mention. There are finally some dreadful machines, which need not be named, fit to make anyone shudder.

The number of visitors to the Exhibition for the week ending Tuesday, 1st September, was 141,786. Total since the opening, 2,499,283.

MICHEL CHEVREUL.

On Monday last, August 31, Prof. Michel Eugène Chevreul entered on his 100th year, having been born at Angers on August 31, 1786. While it falls to the lot of but few to attain such an age, among those whose lives are devoted to science M. Chevreul's case is without any recorded parallel. Almost, too, without a parallel is the amount of work he has accomplished, that has received the double recognition of its value from both the purely scientific standpoint and for its bearings on commerce. In this country, the appreciation of the scientific aspects of the work has been marked by the Royal Society, which, in 1826, elected him a foreign member, and, in 1857, awarded him the Copley Medal, while its practical importance has been recognised by the Society of Arts, which, in 1873, voted to him the Albert Medal. The terms of the award indicate the wide range of his work. It was made "for his chemical researches, especially in reference to saponification, dyeing, agriculture, and natural history, which for more than half a century have exercised a wide influence on the industrial arts of the world." In his own country the double recognition has been equally marked. In addition to honours from scientific societies, and to his appointment to professorships and posts of importance, the Société d' Encouragement pour l'Industrie Nationale awarded to him, in 1852, a *prix* of 12,000 francs. M. Dumas, in formally presenting the prize, referred to M. Chevreul's work in these terms:—Le prix consacre l'opinion de l'Europe sur des travaux servent de modèle a tous les chimistes; c'est par centaines des millions qu'il faudrait nombrer les produits qu'on doit à vos découvertes."

The first of his communications on scientific subjects was in 1806, when he was but 20 years old, and the immense number he has published since then is some indication of his ceaseless industry in the laboratory, though the enumeration merely of titles gives no full conception of the amount of work they describe; for example, his paper, entitled "Moyen de definer et nommer les couleurs, &c.," occupies the whole of vol. xxxiii. of the Memoirs of the Institut, 944 pages in length. His famous work, published in 1823, "Sur les Corps Gras," was based on work, of which he commenced to give papers to the Institut in 1813; whilst his work in connection with dyeing and colours received more attention after

his appointment as Director of Painting and Professor of Chemistry at Gobelins.

It is worthy of special note that an assistant of Vauquelin, and one whose first papers were referred to Berthollet, and who expressed an early hope that his papers might be worthy companions of those of Thenard and Gay-Lussac, still holds a prominent place in the world of science.

OLIVE CULTIVATION IN SPAIN.

Consul Oppenheim says that there are many varieties of the olive tree cultivated in Spain, the better known descriptions being the *Manzanillo*, *Sevillano*, *Gordal*, *Bellotudo*, *Redondillo*, *Lechin*, *Nevadillo blanco*, *Varal blanco*, *Empeltre*, *Racimal*, *Verdejo*, *Madrileno*, and the *Cornicabra*. Each of these varieties can be reproduced in several ways, but the method of propagation generally adopted is either by *estacas* or by *garrotes*. Both these methods are followed throughout the whole of Spain, though in the central provinces the second process is more general, while the contrary holds good for the south and the extreme north. The time chosen for planting is from January to March in the maritime zone, from January till April in the central provinces, and from January till May in the north. The *estaca*, which is a stout limb of the parent tree about three yards long, is planted immediately after being cut from the tree; a hole is dug to a depth varying between one and two yards, the depth increasing with the severity of the climate. Square pits, about three quarters of a yard each way, are considered to be the best for the purpose. At the bottom of the pit a layer of manure is first deposited, upon which a layer of soil is placed; the limb is then placed in the centre of the pit, and earth is then put in, thoroughly broken up, and pressed down with the feet. In Andalusia it is usual to pile up moist clay against the protruding part of the *estaca*, until no more than about a foot of its length is visible; and this is considered to be very efficient in hot, dry regions, as otherwise it often happens that the limb produces shoots from the lower part only, while the upper part becomes dried up. The moist clay is piled up in the form of a slender cone, and at half its height an opening is left for supplying the limb with water, which in dry weather is done plentifully. The *garrotes* are cuttings of from two to three feet long, and for these the pits are dug somewhat less deep than for the *estacas*, and two of the *garrotes* are planted together, leaning towards each other in such a position that the two cuttings and the bottom of the pit form a triangle, of which the apex is even with the ground. In regard to manuring and filling the pit, the process is the same in both methods of planting, only the upper part of the smaller cuttings must be covered with a little loose soil. The sprouts from these smaller cuttings are more exposed to damage by frost and by animals, and the bearing age is also reached some four or five years later; but it is considered that the trees cultivated in this way are more hardy and productive. During the first eight or ten years after planting, the orchard is ploughed three times a year, and the soil immediately surrounding the plants hoed three times the first and second year, and later twice a year. Manuring is usually effected once every three years, and the autumn is the period generally chosen for this operation. Plaster from old walls is considered to be a beneficial addition to the stable manure ordinarily used, and calcined bones are known to expedite the growth and increase the yield of oil. It has been stated that one hundred kilogammes of manure increase the product of each tree the first year by over two kilogrammes, the second year by three, and the third year by two kilogrammes again. Artificial irrigation is resorted to only in dry regions, or in times of drought; as a rule the grown trees thrive very well without it. In Saragossa irrigation is largely resorted to, as is also manuring, while in Seville there is very little of either. The time at which the olives ripen varies considerably, according to locality and the species cultivated. In Andalusia, when intended for pickling, they are picked usually about the middle of September, and the pickling lasts until the middle of October; at that time the fruit has reached its full development, as far as size is concerned, but is yet green and hard. When the fruit is required for the extraction of oil, the harvest commences in November and sometimes lasts until January. The usual mode of gathering is by knocking the fruit down with sticks, but careful growers pick by hand, which is less expeditious but more profitable, as the fruit is obtained in a better condition. For pickling there are two methods employed, the first, which is a very slow process, being as follows:—The freshly picked olives are placed in water, which must be changed every day, and allowed to remain a fortnight; at the expiration of that time the water is quickly drawn off and promptly replaced, not leaving the fruit exposed to the air more than is absolutely necessary. The water drawn off is at first very bitter, and this bitter taste will go on decreasing day by day, the taste being taken as a criterion as to when this process is to be considered as completed, a fortnight being the time usually required. The olives are then placed in a solution of salt and water, generally in barrels, in which wine or brandy has been kept. At the bottom a layer of olive twigs and leaves is first placed, which protects the olive from injury by pressure, and on the top of the fruit another similar layer is placed, care being taken to have this layer well covered by the brine. The whole is kept down by oak staves weighted with bricks or stone, all of which are kept scrupulously clean, as any noxious taste or flavour imparted to the brine will effect the olives, and the vessels are then covered with a cloth or tarpaulin in order to exclude the dust. Olives thus treated will be in good order for boiling or for consumption in

about four months, and will keep sound for two years. For pickling by a quicker process, a solution of caustic soda is prepared, and the fruit placed therein. After remaining in soak about one hour, a few olives are sampled by cutting, in order to ascertain how far the solution has penetrated the pulp; the depth of such penetration being easily seen by the colour, and it should not exceed half the thickness of the pulp. When the olives are in proper condition, the solution is immediately drawn off, and replaced by fresh water, which must be changed quickly three or four times, the fruit being allowed to remain in the last water for twenty-four hours. During that time the brine is prepared, and the next day the olives are placed in it. By this method of pickling, the olives will be ready for use within thirty days. In both processes the olives, after once being wetted, are never exposed to the air more than a few minutes at the time, and in handling the fruit, ladles of wood or tin are use invariably. The extraction of oil is effected in many ways, some of them being very primitive. The first pressing is generally done by means of a mill, and the mass, when reduced to a pulp, is soaked in hot water, and is then subjected to a second pressing, which in the Seville district is usually accomplished by means of hydraulic machinery. The refuse of the second pressing is used as fuel, and in some cases as cattle fodder. Recently a new process has come into vogue, whereby a further quantity of fatty matter is extracted which is used for making soap. Where it is not thought advisable to utilise the refuse in any of these ways, it is employed as a fertiliser for the olive groves. It is estimated that the yield of oil generally averages from about 16 to 25 per cent. Consul Oppenheim states, in conclusion, that a considerable export trade both in olives and in olive oil is carried on in Spain, the amount of the former shipped in 1882 exceeding 1,722,000, and of the latter 13,730,000 kilogrammes, the principal countries of destination being the United Kingdom, France, and Cuba.

General Notes.

Use of the Eucalyptus in Removing Boiler Scale.—It has been stated that eucalyptus leaves possess considerable power in removing the scale from boilers, and that a small quantity put into the water not only prevents scaling, but ina very short time causes the old scale to drop off.

Petroleum in Italy.—The existence of petroleum in Italy is well known, but hitherto the sinking of wells, from one cause or another, has not been attended with success. Lately a small company has sunk a well at Tabiano, between Parma and Modena, which yields 450 litres (about 100 gallons) per day of oil. It is 145 milimetres deep, and the pumps are worked by a 10 horse-power engine. The same company propose shortly to sink another well not far distant to a depth of 430 milimetres, when they anticipate meeting with a large supply of petroleum.

Suez Canal.—According to an Italian consular report the number of ships that passed through the Suez Canal in 1884 was 3,168, of which 2,474 were British, 300 French, 145 Dutch, 130 German, 65 Austrian, and 54 Italians. The total amount of dues paid by these vessels was 62½ million francs (2½ millions sterling).

Fiftieth Anniversary of Railways in Belgium.—On the occasion of the *fêtes* held to commemorate the fiftieth anniversary of the introduction of railways in Belgium, the following statistics have been published:—The number of locomotives in the kingdom at the present time is 1,740, that of passenger carriages 3,367, whilst there are no fewer than 42,722 trucks and vans. The total number of *employés* and workmen is 40,459. During the half century, the Belgian railways have carried 738,798,835 and 330,943,822 tons of goods and luggage. The gross earnings during this period amounted to 2,866,164,228 francs. It is estimated that, had the above number of passengers and merchandise been carried by dilligences and carts, as previous to 1835, the total cost would not have been less than 12,454,911,542 francs.

Tea Cultivation in the Punjab.—Steady progress continues to be reported in this industry. In 1883, there were 1,894 tea gardens in existence, showing a slight advance upon the previous year. Out of the total number of gardens, only 44 are European plantations, the remainder being worked and owned by natives. The total area under cultivation is returned as 9,056 acres, of which 5,708 acres, and 2,256 acres, represent the area under mature and immature plants respectively, and 1,092 acres the area taken up for planting, but not yet planted out. In 1883, the total out-turn of tea was 1,300,000 lbs., of which 984,405 lbs. was black tea, and 315,605 lbs. green. Of the total out-turn, 899,957 lbs. was the yield of the European plantations and 400,053 lbs. that of the native gardens. Compared with 1882, there was an increase in the out-turn of 81,491 lbs. The increase was due to the European gardens, and occurred chiefly in the manufacture of black tea. The average yield per acre of mature plants was 209 lbs. to 257 lbs. per acre on European plantations, and 147 lbs. on native gardens. The cost of cultivation per acre was Rs.64 4a. for European gardens, and Rs.27 9a. for native, while the cost of manufacture per pound was 4 annas and 3 annas respectively. The area under mature plants has been enlarged during the past year, but that under immature plants is stationary. The yield in black tea was much larger, while that of green tea was less. On the whole, the quantity given to the market exceeded the outturn for 1882 by nearly 100,000 lbs. The seasons were favourable, and the difficulty in disposing of the produce was sensibly diminished.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

EXAMINATIONS, 1886.

The Programme for 1886 is now ready. Copies can be obtained gratis on application to the Secretary.

Proceedings of the Society.

CANTOR LECTURES.

CHEMISTRY OF PIGMENTS.

By J. M. Thomson, F.R.S.E., F.C.S.
Demonstrator of Chemistry at King's College, London.

Lecture I.—Delivered February 23, 1885.

It would be impossible, in the time at my disposal, to treat of every colouring material at present employed, even were I to devote myself solely to the consideration of such pigments as are used by artists in the finer departments of painting. I propose therefore, in the two lectures I am about to give, to take into consideration, firstly, some points with regard to the relation of colour to the composition of the substances possessing these different colours; and, secondly, to pass under review some of the properties of the more common pigments, arranging them in the following classes, namely, (1) Whites, (2) Reds, (3) Yellows, (4) Greens, and (5) Blues.

With regard to the first question, namely, the relation of colour to composition, it will be found that, on examining the majority of substances which evince the property of colour, they may roughly be divided into two large classes—those substances which change their colour under the application of heat or other circumstance, but retain still the same chemical composition after this change of colour has taken place as they originally possessed; and those substances which in changing their colours also change their composition. Instances of the first class are to be found in the ordinary red pigment, vermilion, the change of colour of which I can readily show you on the lecture table. In this boiling-tube I have formed from a salt of mercury the black variety of mercury sulphide (HgS), by precipitation with a polysulphide of ammonium. At first, as you see, the precipitate formed is black; but now, on boiling the contents of the tube for some time with an excess of the polysulphide, we find the colour changed into a red colour, comparable to a certain extent with the rich colour of ordinary vermilion.

A similar instance of change of colour without change of composition may be evinced to you in the case of another mercury salt, namely the iodide of mercury, a body possessing, like one variety of the sulphide, a brilliant red colour. I have here a sheet of paper spread with a small quantity of the red iodide; on gently warming this over the large burner, you see that it at once changes into a yellow colour; this is the yellow variety of mercury iodide, and, so far as its chemical composition is concerned, is the same as the red body, viz., HgI_2. On drawing, however, a cross or line across this substance on the sheet of paper, and exercising some pressure upon it, you will at once perceive that the yellow variety is changed back into the red wherever the pressure has been exercised. This change of colour, as many of you are aware, is probably due to a change in the crystalline form of the substance, but not in its chemical composition. Several other substances might be taken as instancing the same kind of phenomena, but I think that those cases which I have shown you are sufficient to illustrate that, in many cases, the colour of the substance is quite independent of the composition, substances having an identical chemical composition, undergoing under different circumstances a change in colour.

A large number of instances, however, may be found in the case of substances in which the change of colour is found to be invariably accompanied by a change of composition.

Instances of this kind may be seen in almost every class of coloured bodies that we are acquainted with, and are especially to be remarked among coloured metallic salts which contain differing quantities of water in their composition. The changes such bodies undergo in their colour have been the subject of many investigations, the later ones carried out by Dr. J. H. Gladstone and Professors Hartley and Russell, who have examined very fully the spectra given by solutions of these salts under different conditions of hydration.

As instances of changes of this nature, we have the alteration in colour which accompanies the heating of the blue crystals of copper sulphate. Here we have some crystals of this body contained in the retort before us, and which, at the present time, may be represented by the chemical formula, $CuSO_4\ 5H_2O$; when the temperature rises, a certain quantity of the water they contain is driven off, the material in the retort becoming converted into the body, $CuSO_4\ H_2O$; and, finally, if the temperature rises sufficiently high, into the substance, $CuSO_4$, or the anhydrous sulphate. At the same time, however, you will see, as the substance changes its composition, it also loses its bright blue colour and distinct crystalline form. That the colour of the body is, however, somewhat closely related to its composition, so far as the water is concerned, may be shown by adding water to the already decolourised body when the blue colour is restored, but not the crystalline form.

By far the most interesting cases with regard to such changes of colour are to be found in certain of the salts of the metals nickel, cobalt, and copper; and in the table on the wall, taken from a lecture of Prof. Hartley's, at the Royal Institution, you will see given the composition of some of these bodies, and the colours they give under the varying conditions.

Substances Varying in Colour, with their State of Hydration.

Anhydrous.	Compounds produced at 100° C. from ordinary Crystals.	Ordinary Crystals.	Colour of Solution.	
			Strong.	Dilute.
$CuCl_2$ Yellow	$CuCl_2\ H_2O$	$CuCl_2 \cdot 2H_2O$ Blue	Grass green	
$CuBr_2$ Black and lustrous	$CuBr_2 \cdot H_2O$ Dark brown	$CuBr_2 . 5H_2O$ Golden green	Red brown	Blue.
$CoCl_2$ Lavender, blue when hot	$CoCl_2 \cdot 2H_2O$ Purple; blue when hot	$CoCl_2 \cdot 6H_2O$ Cherry red..	Deep red..	Blue.
$CoBr_2$ Vivid green	$CoBr_2 \cdot 2H_2O$ Purple; blue when hot	$CoB_2 \cdot 6H_2O$ Deep crimson	Deep crimson	Pink.
CoI_2 Lustrous intense black	$CoI_2 \cdot 2H_2O$ Moss green	$CoI_2 \cdot 6H_2O$ Dusky red-brown	Dark brown	Pink.
$NiBr_2$ Yellow	($NiBr_2 \cdot H_2O$?) Dark red..	$NiBr_2 \cdot 3H_2O$ Green......	Madder brown..	Apple green
NiI_2 Lustrous intense black	($NiI_2 \cdot 2H_2O$?) Dark brown	$NiI_2 \cdot 6H_2O$ Bluish green	Yellowish brown..	Apple green

Perhaps one of the most interesting salts to observe in this particular direction is cobalt iodide, an examination of which has shown that there are two distinct crystalline hydrates, the one formed at high temperatures having the formula CoI_2, $2H_2O$, and possessing a green colour, and another, formed at a lower temperature, containing a much larger quantity of water, CoI_2, $6H_2O$, having a brownish red colour.

The formation of the dihydrate and the anhydrous black compound may be well shown by smearing, as I have already done, the bottom of this porcelain dish with a small quantity of the cobalt iodide, and gently heating over a Bunsen burner. You perceive immediately the almost colourless dish gradually showing a dark spot where the flame of the burner touches it, and as the heat increases, this spot becomes quite black, at the same time it appears surrounded with a ring of green colour, outside of which you may see a second ring of a yellow colour, this finally passing into one of a rose pink, the sub-

stance of which these rings are composed being the different hydrates of the cobalt iodide.

The formation of different hydrates of the same salt, each possessing its characteristic colour, may be seen to very great advantage when we employ a mixture of the two salts, the bromide and iodide of cobalt. Thus, by painting a sketch of foliage and water with these two salts, as has been done for us here before lecture, and gently warming from time to time, most beautiful changes may be produced. At first it has the appearance of a warm sepia drawing, giving to the foliage a rich autumnal tint. On warming, however, the blue of the sky and water and the exquisite green tint of summer foliage gradually appear, and by varying the quantity of cobalt iodide, colours varying between the delicate green of spring-time and the full richness of summer may be produced. On removing now the picture from the source of heat, the atmospheric moisture reforms the original hexahydrated salts, and the brilliant colours gradually fade as the picture cools. In this case the stems of the trees have been painted with a small quantity of nickel bromide, which gives them, upon heating, a rich brown tint, contrasting very well with the green of the foliage.

Passing now to the treatment of the special pigments which it is my wish to put before you, it is my intention to take instances from the different groups which I have already mentioned, and to take them into consideration in the order there given.

By far the most important of the white pigments is the one which is called "white lead," and which is essentially a mixture of the carbonate and hydrated oxide of lead in varying proportions. The preparation of a white resembling the body, prepared on the large scale, may be here illustrated to you by passing a current of carbon dioxide gas through a solution of basic acetate of lead, prepared by dissolving an excess of lead oxide in a solution of the normal lead acetate. In the apparatus on the table I pass the gas through two wash bottles, the first containing a solution of the normal acetate, and the second a solution of the basic salt, and you perceive that little or no white powder is formed in the first bottle, but a dense precipitation takes place in the second, consisting of lead carbonate. This process was adopted by Thenard in France; but the material formed, although pure and brilliant, did not possess that body required for painting purposes, and is not employed to such an extent as the paint prepared by the Dutch method.

It would take too much time to enter fully into the details of the preparation of white lead upon the large scale, but as this colour is one of great importance, I will indicate to you shortly the chemistry of its manufacture. Large gratings of metallic lead are prepared; these being piled or placed in earthen pots, are subjected to the action of the vapours of acetic acid, produced from vinegar placed in suitable vessels. At the same time, carbon dioxide gas is evolved from some material, such as spent tan. Under the influence of heat, the acetic acid volatilises, forming on the surface of the lead a coating of basic lead acetate, which is decomposed in turn by the carbon dioxide becoming converted into lead carbonate, and neutral acetate of lead; this latter, however, becomes rapidly reconverted by the oxygen of the air and a fresh portion of metallic lead into the basic acetate, which is again converted into fresh carbonate by an additional quantity of carbon dioxide. These reactions recurring a great number of times, gradually convert the bars of lead almost entirely into the mixture constituting the paint. This method is generally termed the Dutch method, and is largely carried out in Holland at the present time.

The manufacture of this paint was apparently known to the ancients, having been practiced at Rhodes, at Corinth, and in Lacedæmonia, afterwards passing to the Arabs, and successively to Venice, Holland, England, and France.

The pigment sold in commerce is often adulterated, and should be examined for the sulphates of lead, barium, and calcium, and also for calcium carbonate. For this purpose the oil with which the paint may be mixed must first be removed by successive extractions with benzol, and the powder dried on blotting paper. Pure white lead is soluble in dilute nitric acid, and a sample, when treated with this reagent, should pass entirely into solution, leaving no residue.

The chief drawback to all lead pigments, and especially to white lead, is the ease with which they are blackened by noxious gases, such as sulphuretted hydrogen gas, the sulphur in this gas uniting with the lead to form the black sulphide. In this jar I have some sheets of cardboard freshly covered with some of the paint, and you at once perceive the blackening action of the gas upon the

paint when it is introduced into the chamber. This darkening action may, to a certain extent, be removed by the action of oxidising agents, such as hydrogen peroxide, which, acting on the lead sulphide, converts it into the white lead sulphate. To show you this action, I have here a piece of board with a cross of lead paint already blackened by the gas, I now brush this thoroughly with a moderately strong solution of the hydrogen peroxide, and you see very soon the gradual disappearance of the black sulphide. Many pictures which have become brown or coloured from the formation of such a coating of sulphide may be gently washed with the peroxide, after the varnish has been carefully removed from them; this washing converts the lead sulphide into sulphate, which may be sponged off from the picture with warm water.

The advantage of white lead as a colour depends upon the ease with which it may be spread over a large surface, and the depth of colour or so-called body which the coating possesses. This is probably due to a certain saponification which takes place between the pigment and the oil with which it is mixed, giving to the coating, when first applied, considerable brilliancy. This brilliancy is, however, only temporary when the colour has been applied over one of a darker shade, because the fatty acids contained in the oil gradually expel the carbonic acid from the paint, forming a clear lead soap, through which the deeper colour gradually appears.

The next white colour I would bring under your notice is the "zinc white," or zinc oxide, which is produced on the large scale by the combustion of zinc vapour in air, the oxygen of the air uniting with the zinc to form the oxide. The production of this body on the small scale may be readily shown to you by an experiment which I have here on the table. We have a tassel of zinc foil, tipped with a small wooden match, which I now light, and plunge the lighted tassel into this jar of oxygen, which has been prepared for me. You perceive at once how brilliant the combustion is, and after it has ceased we can collect and examine the product, which will be found to consist of a white powder of great brilliancy.

I will not enter into the details of the manufacture of this paint, but proceed to show you in what way it differs from the one we have already considered. When we examine the powder by itself, it seems just as brilliant, indeed, in some cases, more brilliant than white lead, but when we come to mix and spread the colour, we find that it does not possess that density or opacity which belongs to the lead pigment. It has, however, certain advantages over lead colour, which, in many cases, overbalance its want of body, as it is not destroyed by noxious gases. The reason of this is that the sulphur compound which zinc forms is white in colour, as I can readily show you by the following experiment. I have in this jar a little zinc white dissolved in acid, and the solution diluted with water; I now add some dilute ammonia solution to counteract the acid liquid, and you perceive that at first a white precipitate is formed; this dissolves, however, on the addition of slight excess of ammonia, and on passing some sulphuretted hydrogen gas through the liquid, we form a white body, the zinc sulphide, instead of the black substance we obtained in the case of the lead pigment.

Advantage has been taken of these properties in the manufacture of a form of zinc white called "Griffith's zinc white," which apparently has a brilliancy and body equalling the best forms of white lead. This pigment has for its basis zinc sulphide, this being accompanied by some magnesia in its precipitation. The mixed precipitate is dried, heated to a suitable temperature, and then suddenly cooled. In this jar I have placed some boards painted with zinc white, and you see that no blackening action takes place on admitting the sulphuretted hydrogen gas.

Zinc white may be adulterated with the same substances already mentioned under white lead. If perfectly pure, the oxide should dissolve entirely in dilute sulphuric acid, but if impure, a white residue will be left.

Other white pigments of somewhat lesser importance are prepared. Among these may be mentioned "whitening," or Spanish white, which is prepared by grinding native chalk, or precipitating calcium carbonate; barium sulphate, manufactured in France on the large scale under the name of *blanc fixe*, either by grinding native heavy spar, or by precipitating the sulphate with sulphuric acid from a solution of barium chloride. The pigment so prepared is entirely unacted upon by gases containing sulphur, and so undergoes no blackening action; but, like zinc white, it does not possess the body or covering power which is given by white lead. It is, however, employed to a large extent in distemper painting, and, as already stated, is used for the adulteration of white lead and zinc white. A very brilliant

white may be obtained from another compound of barium, namely, barium tungstate, which may be prepared by precipitation from a soluble barium salt with an alkaline tungstate. I have here a specimen of this white so prepared, and you perceive how extremely brilliant the white is. It suffers, however, from the same fault as the barium sulphate and zinc white, and does not seem to have found much favour with artists. The metals tin, mercury, antimony, and bismuth, also yield white pigments, but they possess no advantage over white lead, and are all blackened more or less by sulphuretted hydrogen gas.

Red Pigments.—I pass now to the consideration of certain of these pigments, firstly, on account of one of the most important of them, namely, red lead, containing the metal lead which we have already found in other pigments; and, secondly, because I will consider the remaining colours according to the order in which they are arranged in the solar spectrum. Red lead consists of an oxide of lead, the chemical formula of which is approximately Pb_3O_4. It is largely used for out-door painting of a coarser kind, but is very little employed by artists, as it has no permanency, and is particularly easily affected by noxious gases. It is prepared by heating "litharge," another oxide of lead, to the required temperature in reverberatory furnaces, great care being taken that the litharge is pure, and the temperature well regulated, so as to obtain the richest colour, the presence of other metals greatly deteriorating the brilliancy.

Red lead is probably a mixture of two oxides, PbO and Pb_2O_3, as we find that treating it with warm nitric acid produces at once a change in the colour, by dissolving out the first, or protoxide, and leaving the brown peroxide. You will perceive this change on the sample I have in this tube, which rapidly becomes brown on my adding to it a little warm nitric acid.

Vermilions.—Common Vermilion, Mercury Sulphide; and Antimony Vermilion, Antimony Sulphide.—The first of these colours I have already alluded to in the commencement of my lecture, in connection with change of colour without change of composition. We have now to consider more particularly its manufacture as a pigment.

The mercury vermilion may be obtained either by the sublimation of a black compound of mercury and sulphur at a high temperature, or by the wet method, which is the one supposed to be adopted by the Chinese in the preparation of the peculiarly rich colour which they obtain. For the first method, the sublimation of the black powder, or "Ethiops," as it is called, is carried out in specially formed earthen pots, heated at the bottom, and carefully cooled at the top, so that the sublimed sulphide may be deposited on the cooled parts of the vessel. The best portions of the sublimate are then picked out, washed, and crushed for sale. In Idria the mercury and sulphur are placed in barrels, which are caused to revolve rapidly, until the entire combination of the bodies has taken place. This forms the black sulphide, which is then placed in iron cylinders heated to dull redness, and fitted with earthen covers and tubes, in which the red variety is deposited. After finely grinding the pigment in water, it is boiled with caustic alkali to remove the excess of sulphur, subsequently being washed and dried.

In the so-called Chinese or moist method, the mercury and sulphur are ground together, when moistened with a small quantity of caustic potash; having been well mixed, more solution of caustic potash is added, and the whole heated on a sand bath, with constant stirring, the heat being gradually and carefully increased, the temperature which seems to yield the best results being a little below 50° C. At a certain point the mixture attains its most brilliant colour, becoming gelatinous in consistency; the operation is then stopped, the vermilion washed with caustic soda and water, and finally dried. In both operations the success depends chiefly on the management of the temperature in the sublimation of the Ethiops, and in the heating of the caustic ley with the mercury and sulphur.

Vermilion may be found adulterated with several substances, chief among which are brick dust, and the chromate and peroxide of lead. Samples of the pigment may be tested for brick dust by simply volatilising some, as I do now, on a piece of porcelain, when the pigment passes off, leaving the brick dust behind. To detect chromate or peroxide of lead, the pigment should be digested with hydrochloric acid, when the smell of chlorine will at once be felt; and should further proof be required, the mixture may be filtered hot, when the lead salt will most probably be deposited in the filtrate, on cooling. Should vermilion be adulterated only with lead chromate, very often friction in a mortar is sufficient to show its presence, as a deterioration in the brilliancy of the pigment takes place.

There seems to be no doubt that vermilion, unless exceptionally pure, undergoes a change through time, gradually losing its original bright red colour, and becoming converted into a brown. This may be explained when we reflect that the great brilliancy of the colour can only be obtained by carrying out its preparation within certain temperatures, and that heating above or cooling below these points does not yield a good colour, pointing to the fact that the pigment cannot be regarded as a perfectly stable body, but is liable to molecular changes which may take place through time or changes of temperature.

Antimony Vermilion, Antimony Sulphide.—This colour may be prepared by passing a current of sulphuretted hydrogen gas through a solution of some antimony salt acidulated with hydrochloric acid, when you see the orange precipitate of antimony sulphide forming.

To prepare the precipitate of a good scarlet hue, pure antimony chloride should be dissolved in water, when at first a white precipitate of antimony oxychloride will be found; on adding a saturated solution of sodium hyposulphite, or calcium hyposulphite, to this mixture, however, the precipitate will quickly dissolve, and on heating the vessel gently to about 30° C., a precipitate will be formed at first of an orange colour, but gradually changing to a brilliant scarlet. The best result is obtained when the temperature is gradually raised to 55° C., when the reaction should be finished if a sufficient quantity of the hyposulphite has been used. After preparation, the pigment should be thoroughly washed, when it will be found to stand well, and already containing sulphur, is not affected by noxious gases.

A red of an extremely brilliant colour, named "iodine scarlet," may be obtained from another compound of mercury, namely, the biniodide. Its formation can easily be shown to you on the lecture table by adding together solutions of potassium iodide and mercury bichloride, when a brilliant scarlet colour is produced. This substance is soluble in excess of either reagent, and the addition of these must be carefully carried out; the best result being obtained by taking eight parts of mercury bichloride to ten parts of the potassium iodide. Although a colour of great brilliancy, it cannot be recommended, as the mercury biniodide undergoes transformation by heat, as already shown to you, and the colour does not withstand the action of sulphuretted hydrogen gas.

Two other compounds furnish pigments of a rich colour termed "purple red." They are the chromates of mercury and silver, and are formed by the decomposition of the nitrates of silver and mercury by potassium bichromate. The cost of such pigments, however, and the fact that they gradually lose their brilliancy, in time, has prevented their extensive employment. The silver chromate was at one time much used in miniature painting.

"*Colcothar or English Rouge*" is a residue of iron peroxide produced in the manufacture of Nordhausen sulphuric acid, and resulting from the decomposition of the iron protosulphate therein employed. If required in a finer condition, it may be prepared either by carefully heating pure anhydrous ferrous sulphate, or by roasting precipitated ferric oxide. This pigment is not unfrequently adulterated with barium sulphate, which may be readily recognised by treating with hydrochloric acid, which entirely dissolves the colcothar, leaving the sulphate unacted upon.

Yellow Pigments.—Ochres.—These pigments consist essentially of clay, coloured with different quantities of ferric oxide, with more or less water attached to it. They comprehend also the colours "raw" and "burnt sienna," and the pigments known under the names of "Antwerp" and "Venice reds." The darker shades of ochre are readily prepared by heating the bodies of a lighter colour, and contain lesser quantities of water in their composition. I have here some yellow ochre in this tube, and you perceive that at once, on the application of heat, it becomes brownish-red in colour, losing water, which collects on the colder portions of the tube. The ochres, as a class, are of no definite chemical composition, but they are extremely stable colours, both under the action of air and noxious gases, and are well suited for outdoor painting.

Chromes.—Next to the ochres, the most important group of yellow pigments are the chromes, which are produced by the combination of chromium, in the condition of chromic acid, with the metals lead, zinc, barium, strontium, or calcium. They are divided into two large classes, namely, "yellow" and "orange" chromes, and I must content myself with showing you generally how these different conditions are attained, without entering into the details of their special preparation. The yellow chromes may be obtained by the precipitation of a salt

of the metal from which the chrome is required, with neutral potassium chromate, as you see on the table before you. In this jar I have a solution of barium nitrate, which, on the addition of a solution of potassium chromate, yields us a brilliant yellow precipitate of barium chromate. In the same way the lead chromate may be prepared, and obtained as a yellow powder of considerable brilliancy and density. The chrome which we have here produced is what is technically termed "lemon chrome," but by mixing this with some other white pigment a lighter shade may be made. This is generally done by mixing with lead sulphate, and we must not, in such a mixture, regard the sulphate of lead added as placed there for the purpose of adulteration, but only as a diluent to the chrome colour. The chromates of barium, zinc, strontium, and calcium, all possess shades comparable with that of the lemon chrome.

Orange Chromes.—These pigments consist of the basic lead chromate obtained by slight differences in the method of preparation, and are generally formed by boiling the neutral chromate with caustic alkali, by which means the chromate associated with an additional quantity of lead oxide is produced. The formation of a simple orange chrome can be easily shown to you by boiling, as I now do, a little of the lemon chrome with caustic lime; you see that, as the temperature rises, a darkening in colour takes place, which may be increased at will by still farther heating. If we regard the neutral lead chromate as possessing the chemical composition $PbCrO_4$, the orange chrome formed from it would have the composition ($PbCrO_4$. PbO), and will evidently be produced by processes of oxidation. In fact, one of the methods adopted for its preparation, namely, that one in which it is formed by adding the neutral chromate to ordinary nitre in a red-hot crucible, depends on this property.

The objection to the chromes as pigments depends on the action of alkalies upon them, which, as we have seen, produce this darkening effect, and, if in excess, exercise a solvent action on the substance. The colours, of course, formed by lead chromate are subject to the same action of sulphuretted hydrogen gas as other lead pigments. Processes of reduction also affect the chromes, giving to them a slight green tint; such a reduction being produced by organic substances with which the colour may be mixed. I have here a small quantity of lemon chrome, which I mix in this tube with a little strong hydrochloric acid and alcohol, when you perceive that, on boiling, the colour rapidly changes, the chromate being dissolved, and, finally, the mixture changing to a green colour, this reduction being produced by the alcohol. The admixture of other bodies with the chromate of lead, such as calcium, or lead sulphates, does not seem to interfere with the colour unless carried to too great an extent, as is done in the case of "Cologne yellow," which contains a large admixture of these two bodies.

Before leaving the yellow pigments yielded to us by lead, there is one substance which might be mentioned, from the brilliancy of its colour, but which is not to be recommended as a durable pigment, that is, the lead iodide. This substance is formed by bringing together solutions of lead nitrate and potassium iodide, when we obtain a beautiful canary coloured precipitate of considerable body. This pigment, however, apart from its decomposition with noxious gases, is easily soluble in hot water, becoming converted into a crystalline variety, which is deposited in that condition on cooling. Other yellow colours containing lead are found in the pigments formed from Massicot (PbO), and in "Turner's yellow," which is apparently an oxychloride of lead.

I now come to two yellow pigments which are definite in their composition, and, in one case, permanent in colour; these are yellow orpiment, or "King's yellow," and "cadmium yellow," the first of these being a sulphide of arsenic, the second, sulphide of cadmium.

King's Yellow may be formed by subliming together flowers of sulphur and arsenious acid, or by making a solution of arsenious acid in water acidulated with hydrochloric acid, and passing a current of sulphuretted hydrogen through the solution. The pigment obtained in both cases has the arsenic tersulphide for its basis, but the body prepared by sublimation generally contains small quantities of free arsenious acid. King's yellow forms but a poor pigment without much durability, and when containing free arsenious acid is poisonous. Another yellow may be formed from arsenic by fusing together litharge (lead oxide) and arsenious acid, and is sold under the name of "mineral and arsenic yellow;" the fused mass must be thoroughly ground to secure perfect homogenity of the pigment.

Cadmium Yellow.—Sulphide of cadmium prepared in a manner similar to that indicated for King's yellow may, I think, be regarded

as one of the most permanent of the yellow pigments. It mixes well with other colours, and, as it is not easily decomposed, has no tendency to deteriorate lead pigments. It may be obtained in different shades, according to the proportions in which the ingredients forming it are taken, this constituting a little difficulty in its preparation for the trade. You can readily judge of the ease with which it may be obtained, by my adding some sulphuretted hydrogen to this large vessel of water, containing a little of a salt of cadmium, when a brilliant yellow precipitate of cadmium sulphide is obtained. The last yellow pigment to which I would specially draw your attention is the one which is sold under the name "Aureolin." It is a somewhat complex compound, produced by the precipitation of a salt of the metal cobalt with potassium nitrite, when the solution is strongly acid with acetic acid. In this flask I have such a solution of cobalt sulphate rendered acid with acetic acid; to this I now add excess of potassium nitrite. At first, no precipitate is seen, but on standing, a brilliant yellow powder, consisting probably of the double potassium and cobalt nitrite, begins to be formed, this increasing on the mixture being allowed to stand. This pigment, when prepared in a pure condition, is strongly to be recommended, as it is entirely unacted upon by gases containing sulphur, and, when in a pure condition, withstands the action of weak alkalies.

Various other bodies yield us yellow pigments of greater or less brilliancy and durability, such as Turner's yellow, and the yellows sold under the names of Cassel, Montpelier, and Verona yellows, which are all oxychlorides of lead. They are not worthy of special notice, and I will therefore content myself with merely mentioning them.

In my next lecture I propose to take up the consideration of certain pigments yielding us green and blue colours.

The following tables give some of the more common pigments, arranged in groups according to their more or less poisonous properties :—

FIRST GROUP.

Pigments Dangerous to Health.

Orpiment (arsenic sulphide).	White lead.
Realgar.	Massicot.
Mercury biniodide.	Litharge.
Turbith mineral.	Minium.
Lead arsenite.	Naples yellow (lead antimoniate.)
Lead oxychloride.	Scheele's green (copper arseniate).
Lead sulphate.	Prussian blue.
Cobalt arseniate.	Prussian green.
Verdigris (copper acetate)	

SECOND GROUP.

Pigments less Dangerous to Health.

Lead chromate.	Zinc oxide.
Vermilion.	Zinc chromate.
Tin sulphide.	Barium chromate.
Mineral lake (tin chromate).	Antimony oxychloride.
Copper chromate.	Cadmium sulphide.
Purple red.	Smalt.
Thenard's blue.	Ultramarine.

THIRD GROUP.

Non-Poisonous Pigments.

Carbonate of lime.	Raw sienna.
Barium sulphate.	Burnt sienna.
Yellow and red ochre.	Cologne or Cassel earth.
Venetian red.	Sepia.
Mars red.	Ivory and lamp blacks.
Cochineal or carmine.	Indian ink.
Manganese brown.	Colcothar.
Vandyke brown.	Indigo.
Raw umber.	Terra verte.
Burnt umber.	

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The number of visitors to the Exhibition for the week ending Tuesday, 8th September, was 137,491. Total since the opening, 2,636,774.

FORESTRY.

A Select Committee of the House of Commons was appointed on Friday, May 15th, "to consider whether, by the establishment of a Forest School, or otherwise, our woodlands could be rendered more remunerative;" and on July 8th, the following members were nominated:—Mr. William Corbet, Dr. Farquharson, Mr. Fremantle, Mr. William Henry Gladstone, Sir G. Macpherson Grant, Sir John Kennaway, Sir Edmund Lechmere, Sir John Lubbock, Dr. Lyons, Sir Herbert Maxwell, Colonel Nolan, Mr. Parnell, Mr. Plunket, Mr. Portman, Mr. Round, Mr. Seely, jun., Mr. Moore Stevens, Mr. Villiers Stuart, and Mr. Northcote. On July 16th, Colonel King-Harman was added to the Com-

mittee, in place of Mr. Northcote. The Committee held three meetings, with Sir John Lubbock as chairman.

The following draft report was agreed to on July 24th:—"Your Committee are of opinion that at this late period of the session it will not be in their power to conclude their investigation; they have therefore agreed to report the evidence already taken to the House, and to recommend that a Committee on the same subject should be appointed in the next session of Parliament." The evidence has now been printed and issued to the public.

The first witness examined was Mr. William G. Pedder, head of the Revenue Department of the India-office. The forest organisation in India, he said, originated in 1846; and in 1863, further steps were taken to secure the scientific training of Indian forest officials. Last year the gross revenue had risen to nearly £1,000,000, and the net revenue to nearly £400,000. But the improvement which has taken place in the forests was a much more important element than the mere increase of net revenue. The forests were in course of being so completely destroyed in the various parts of India that the duty of the Forest Department had been rather to conserve them. He thought that, by the improvement of the education of our forest officials, we might produce somewhat similar improvements in England to those which have resulted in India. Forest schools existed in Germany, France, Russia, Italy, and Switzerland. Believing there might be some improvements effected in training the forest officials, we requested the French Government to send over an experienced officer to examine and report upon the state of the English woodlands, and the authorities sent over Professor Boppe, who made a tour of inspection of some of our forests, accompanied by Colonel Pearson, then forest officer at Nancy, and some of the stndents. He made a report, which witness handed in. In this report, the Inspector of French Forests says that were it only for the pupose of replanting the five or six millions of moor and waste land which cover one-third of the Highlands, he should consider there was a sufficient reason for the formation of a Forest School. He recommended that a National Forest School be founded in Great Britain, and that Professorships of Sylviculture be instituted at Cooper's Hill and at Edinburgh. Mr. Pedder expressed an opinion that in twenty or thirty years hence, when the result of what is now done has become apparent, the net returns of the revenue from the Indian forests will become very much larger. The Indian Government established their school at Dehra Dun because it was desirable that officers, even of the lower grade, should have some special training. It had only been established for five years, so that they could not tell yet what the result of it might be. There was nothing of the same kind in Great Britain at present. At Kew there was a magnificent school of botany, but not of forestry. He believed the establishment in England of a similar school to that of Dehra Dun would be advantageous.

Colonel James Michael, who was at the inception of the Forest Service in India, said he concurred with the foregoing evidence. He thought the management of our woodlands, in England, might be improved, and that a forest school in this country would have very beneficial effects. There was a good deal of land in England and Scotland which would bear planting. Timber in this country would always pay for its carriage.

Dr. Hugh Cleghorn, who was for twelve years conservator of the Madras forests, said he also concurred in Mr. Pedder's views. It was unquestionable that, if we had more trained officials, our woodlands would be rendered more remunerative; and it was marvellous that we should not at an earlier date have begun to adopt some means to preserve them. The establishment of a Forest School in each of the three kingdoms would be a great advantage to this country. The supplies of timber coming from abroad were rapidly diminishing, and it was of great consequence that we should endeavour to increase our own production. There were many places in this country exceedingly suitable for planting, but it would be necessary to exclude sheep for perhaps thirty years.

Colonel Pearson, who represented the Indian Government for eleven years at the Forest School at Nancy, said he had the general charge of the forest students, and had been through most of the principal French forests. He had also been through the British forests with the French professors. Several English colonists had applied to him for officials to take the management of forests, and, being unable to find any qualified Englishmen, he had been obliged to recommend French officials. The school at Nancy was an admirable one, and had done great service by instructing a very able body of men, who were now carrying on good work in India. He was in favour of supplementing the general education given in this country by giving a special forest education in some convenient place, where there should be a museum supplied, with an instructor in forestry, who might give lectures on the subject, and conduct the pupils from time to time into difficult forests with the view of enforcing the instruction of the lecture-room. A forest school might be set up in this country for an expenditure of £600 per annum in salaries. He did not know one mature forest in England or Scotland at present, and, therefore, for an important part of the instruction relating to the removal of the crop, the students would have to go abroad. It would be desirable to interest in this subject persons concerned in the education of land agents. We should suffer in the future if this matter were not taken up now. He would give three courses—elementary, for the wood manager; more advanced for the land agent; and a higher course for the man who wanted a thorough education; but for the complete course men ought

to go to the Continent. There was one spot in the Forest of Dean especially suitable for instruction; but neither there nor in the New Forest could anything be shown regarding the management of conifers.

Mr. W. T. Thiselton Dyer, Assistant Director of the Royal Gardens, Kew, said Kew performed, to a large extent, the part of a botanical authority to the Government, and when the Colonies applied for information, the Government sent to Kew for assistance. It had been found impossible to recommend to the Colonial-office properly qualified persons either to report upon or to manage colonial woods. Apart from the trained officials of the Indian Forest Department, it was practically impossible to meet the requirements of the Colonies; and that department had only spared men temporarily, which had caused great inconvenience. A good many of our Colonies had now come to that state of things that there will probably be a demand for persons who understood the management of forests. He would make the demand for India a kind of nucleus of a school which should be utilised for the education of such gentlemen as wished to undertake colonial service, and for the instruction of land agents and persons competent to give advice as to our own woods.

Mr. Julian C. Rogers, secretary to the Surveyors' Institute, said he agreed with the previous witnesses as to the general advisableness of instituting a Forest School, both for this country and for the Colonies.

The report of M. Boppe on a visit to the English and Scotch Forests, by the professors and students from Nancy Forest School (see *Journal*, vol. xxx. p. 772) is printed as an appendix to the report of the Committee.

AGRICULTURE IN ECUADOR.

Consul Beach, of Guayaquil, says that Ecuador covers an area of 150,000 square miles, and has a soil and climate scarcely equalled by any other country in the world. About one-fourth of the extent is of tide water level, and the remaining three-fourths of various altitudes embracing hills, mountains, and mountain valleys, the highest altitude being that of Chimborazo, 21,220 feet. There are about twenty mountain summits that are more than 10,000 feet in height. The great difference in altitude will serve as an explanation of the wide diversity of climate and variety of soil productions, both of which are much greater than would be considered possible in the equatorial region. The mountains, though all of volcanic origin, are yet somewhat varied in their elements, but each has the characteristic of quite rapid decomposition, which decomposition provides a soil more or less fertile for all of the mountain surfaces, and affords abundant material to be carried down by the streams to the mountain valleys, and to the level lands adjacent to the numerous rivers in the lower sections. Ecuador, on both sides of the Andes, abounds in rivers and smaller streams, which greatly enhance the productions of the country, and the rivers themselves provide a water communication with the markets. The climate is exceedingly diversified, having the wide range from an average temperature of 75° Fahrenheit on the Pacific Coast and upper tributaries of the Amazon to that of the summits of the Andean range, where there is perpetual snow and ice. Between these extremes there are all the degrees of variation from the tropical to the arctic. The difference of temperature resulting from the difference of altitude permits the growing in Ecuador of nearly all the fruits and varieties of grain and vegetables grown in all other parts of the world. Everything pertaining to the tropics is produced in profusion, and in addition, wheat, oats, barley, apples, pears, peaches, cherries, strawberries, and vegetables of every kind. Consul Beach says that Ecuador has many natural advantages that might be rendered a great blessing, but the people appear to be wanting in the main essentials of industrial progress, and the country makes but trifling advancement, as may be seen by an examination of the agricultural implements now in use. The implements of most varied uses is the *machete*, a heavy blade about two inches in width, two feet long, with a handle about five inches long. Most of the blades are straight, but some of them have a slight upward curve. A field is prepared for rice by cutting down all the weeds and bushes with a machete; an opening for the seed is then made with a broad-ended bar, and the seed dropped in. When the rice comes up, the grass and weeds between the rows are cut with machetes, which operation is repeated at intervals. For Indian corn and sugar cane the land is prepared in the same manner, and the planting and cultivating is performed with the same tools, and in the same manner as previously described. The rice is cut with sheath knives, and the corn and cane with machetes. The rice, after being cut and cured, is first trodden out by peons or labourers, and then put into large wooden mortars, and milled by the use of large wooden pounders wielded by peons. Ploughing is done in the interior, for grain and potatoes, with ploughs made by pointing round sticks with iron—these implements being very similar to those in use in many parts of Italy. There are no harrows, field rollers, cultivators, reaping and mowing machines, drills or horse rakes. In the cultivation of potatoes and other vegetables large hoes are used. Timber-cutting and hewing are done with broad axes, and the timber sold is drawn to the rivers by oxen, having yokes strapped to their horns, and a pole strapped to the yoke. Chains are not used, the logs being attached to the ox-pole by raw hides. The small wood, from three inches in diameter downwards, is cut with machetes. On the plantation no saws are used, but the tools chiefly in use are machetes, hoes, iron-pointed stick ploughs, bars (wedge-shaped at one end), sheath knives, and broad axes.

ELECTRICAL ILLUMINATION OF OBJECTS FOR THE MICROSCOPE.

In his "Synopsis des Diatomées de Belgique," Dr. H. Van Heurck observes that the electric light enables the observer to see, without difficulty, details which are invisible or but imperfectly visible with ordinary means of illumination. The reason he gives for this is, first, because the electric light contains more blue and violet rays than the light of lamps or gas; and secondly, because it has a specific intensity considerably greater than other artificial light, and therefore permits the use of much more oblique rays. The results obtained by Dr. H. Van Heurck have been confirmed by Dr. Von Voit, of Berlin; Dr. Stein, of Munich; and Prof. Max Flesch, of Berne, who have satisfied themselves that the incandescent form of electric light affords the illumination *par excellence* of the micrographer.

The electric illumination of the microscope has entered upon a new phase through the Trouvé apparatus, which can be used for the most difficult investigations in micrography and photo-micrography. The battery consists of a small ebonite box, the inside of which is divided for two-thirds of its height into six compartments, communicating at the bottom by a small aperture between each. The elements, each consisting of two rods of amalgamated zinc placed between three carbon rods, are attached to the cover, being coupled in tension, and may be let down into the liquid, or withdrawn therefrom, or more or less immersed according to the power required at the time.

The illuminating apparatus, attached to the front of the battery, or made to slide with universal joint on a standard, so as to throw its light in any direction desired, is the Hélot-Trouvé photophore, originally devised for surgical operations and the examination of the cavities of the body. The photophore consists of a nickelised brass tube, in which the incandescent lamp, of special form with a straight filament, occupies the middle. At the back end is a reflecting mirror, and at the front a condensing lens with adjustment, by which converging, diverging, or parallel rays may be obtained. As the light from the reflector might be objectionable in certain very delicate observatious, a small blackened disc is added for covering the reflector at will, and a diaphragm may be placed on one or other side of the lens for intercepting the light from its edges.

The battery is capable of maintaining the lamp for two hours, producing a light which may be utililised in certain cases of photo-micrography, but which is much too intense for ordinary microscopic research. By a slight modification of the battery, however, by which only three or four of the elements are coupled, and the rest added as the battery becomes exhausted; or by employing a lamp of slighter power, the exact degree of light required may be obtained. The battery evolves no fumes, and the expense of maintenance is very slight. The charge, including loss of zinc, costs 2d., that is to say, 1d. per hour, or a halfpenny an hour if the small Steam lamp be used.

Correspondence.

PHILOSOPHICAL INSTRUMENTS AT THE INVENTIONS EXHIBITION.

My attention has been called to a letter in your *Journal* from Mr. S. Tate, professing "to point out some errors in the criticism of calculating machines by Professor H. M'Leod." Would you allow me to correct a seriously misleading statement which it contains in reference to my circular machine?

Mr. Tate says I have "lately been obliged to apply springs," and, by implication, he intimates that these are in place of the springs which (as stated by Professor M'Leod) I have "entirely eliminated." This is altogether incorrect. There are no springs in my machine upon which "the fixity of the number discs" depends when in operation. Such springs *have been* "entirely eliminated," and I have no reason to replace them by others of any form.

The springs which, according to Mr. Tate, I have "lately been obliged to apply," have a different purpose; and even in regard to these he is mistaken. I have always had springs for that purpose. Those "lately applied" are simply of an improved form. The "circle" or "circular slide" is occasionally lifted out of the machine, and it is the duty of these springs to steady the discs till the circle is replaced. They have nothing to do with the reckoning; they are quite stationary, simply exerting a slight but constant pressure, and consequently cannot get out of order.

The correct action of all other arithmometers (Mr. Tate's included) depends upon the springs which I have eliminated. Although they are at rest during considerable intervals of the machine's working, they make at the rate of over 4,000 vibrations per minute when in action, and their absence from the circular machine is considered to be one of its great recommendations.

JOSEPH EDMONDSON.

Halifax, September 2nd, 1885.

Notes on Books.

DRAUGHT. The Worshipful Company of Coach Harness Makers' First Prize Essay, by William Philipson, Newcastle-on-Tyne. London: J. Kemp and Co. 1885. 8vo.

The author points out in his preface that the question of draught has hitherto been chiefly treated

either in regard to its relation to the improvement of roads, or to the capabilities of horses. His object is to work out the subject entirely in its relation to the carriage. The essay commences with this statement:—"The draught of a carriage is mainly composed of the resistances offered to the motion of the wheels, which are caused by (1) the resistance offered to the rolling of the tyre on the road, (2) the friction of the metal box round the axle arm, (3) the force of gravity, (4) the speed at which the wheel is driven." The author then proceeds to explain the cases of these various resistances. The essay is illustrated by engravings which show how the theory may be adapted in practice to different forms of carriages.

LUNACY IN MANY LANDS: Being an introduction to the Reports on the Lunatic Asylums of various countries visited in 1882-5 by G. A. Tucker, and presented to the Government of New South Wales, Australia. 8vo.

Dr. Tucker, Superintendent of the Bay View Lunatic Asylum, near Sydney, has visited the chief madhouses in Europe and America, during the last three years, and this volume contains the result of the information he obtained in the form of abstracts of the various reports of institutions which came under his notice; this information he has collected for the benefit and information of the Government of New South Wales.

A TREATISE ON THE MANUFACTURE OF SOAP AND CANDLES, LUBRICANTS, AND GLYCERIN. By Wm. Lant Carpenter, B.A., B.Sc. London: E. and F. N. Spon. 1885.

In this volume Mr. Carpenter deals first with the manufacture of soap. Three chapters are devoted to the raw materials, one to caustic alkali and other mineral salts, one to the manufacture of household soaps, one to the treatment of soap after its removal from the soap copper, and one to the theory of the action of soap. Chapters follow on the lubricating oils, and the manufacture of candles and glycerin. The fourteenth chapter contains a summary of patents, and the last chapter a bibliography of the subject. The volume is illustrated.

SOLUTIONS OF THE QUESTIONS ON MAGNETISM AND ELECTRICITY SET AT THE INTERMEDIATE SCIENCE AND PRELIMINARY SCIENTIFIC PASS EXAMINATIONS OF THE UNIVERSITY OF LONDON, FROM 1860 TO 1880. By F. W. Levander, F.R.A.S. Second edition. London: H. K. Lewis. 1885.

The first edition of this little book contained solutions of the questions for twenty years, and in this second edition considerable alterations have been made with the addition of solutions of questions set for the last five years. The subjects of the questions are arranged under the headings—Magnetism, Terrestrial Magnetism, Static Electricity, Dynamic Electricity, and Thermo Electricity, with a chapter on Miscellaneous Questions.

A HAND-BOOK OF HYDROMETRY. By James Boddely Keene. London: Pitman.

The object of the author, who is connected with the Hydrometer-office, Custom-house, is stated to be the simplification of the science, and the popularisation of the use of the instrument. The most important forms of hydrometers are described, as well as some improvements made by the author. Tables of specific gravities are given in an appendix.

TEA AND OTHER PLANTING INDUSTRIES IN CEYLON IN 1885. Colombo: A. M. and J. Ferguson. 1885.

In this pamphlet tea cultivation is chiefly dealt with, but the other planting industries, such as cacao, cardamoms, cinchona, coconut and areca palm, are also described; and the object of the author is to show how far Ceylon is a satisfactory field for the investment of British capital and energy.

General Notes.

PICTURE FRAMES.—Picture frames are now made in Europe with a composition consisting of paper pulp, glue, linseed oil, and carbonate of lime or whiting, which is heated and mixed to the consistency of thick cream; it is allowed to cool, after which it is poured into suitable moulds and allowed to harden. The frames are then gilt or bronzed in the usual manner.

PAPER FOR BUILDING PURPOSES.—The *Illustration* states that a manufacturer of Breslau has built a chimney 16 metres high (51 ft. 6 in.) entirely of paper. The blocks used in its construction, instead of being of brick or stone, were made of layers of compressed paper, jointed with some siliceous cement. This chimney is very elastic, and at the same time is fireproof, and is less liable than ordinary ones of being struck by lightning.

ITALIAN ENTERPRISE IN SOUTH AMERICA.—It appears, from the *Patria Italiana*, published at Buenos Ayres, that one of the most important paper manufacturers in Lombardy intends establishing large mills near that city. The Impresa Industriale Italiana, of Naples, a company which of late years have carried out a large number of bridges in Italy and Austria, have recently completed a bridge for the Government of the Argentine Republic, and are now in treaty for several others of considerable importance. The machinery for the harbour works of Ensenada has been made by Messrs. Cravero, of Genoa, and further commissions for machinery and ironwork are in the hands of Italian manufacturers.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Mr. J. M. Thomson's second lecture on the "Chemistry of Pigments" will be published in the next issue of the *Journal.*

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

GROUP XXIX.—PHOTOGRAPHY.

By W. B. Bolton.

The period covered by the present Exhibition may, roughly speaking, be said to comprise half the lifetime of photography, a science which has sprung into practical being within the last half century. The first portion of that time saw the young art struggle through various forms of existence, in some of which it was little better than a scientific curiosity; but, five-and-twenty years ago, it had fairly assumed a practical and industrial position, and had commercially, as well as from an art point of view, secured a firm hold on popular favour. Since then, the growth and progress of photography have been rapid and important, and its applications have extended into nearly every branch of art, science, and industry, though comparatively few of these applications are exemplified in the present Exhibition.

So far as the early processes are concerned, these are fairly represented in the collection brought together by the Photographic Society of Great Britain, which, though less complete than could have been wished, gives a tolerably good idea of the various stages through which the early science passed previous to the Exhibition of 1862. Commencing with some specimens of heliographic engraving, executed by Nicephore Niepce as far back as 1827, this interesting collection comprises examples of each successive process of importance since introduced, including in turn Daguerreotype, the first really practical method of "sun-painting," Calotype or Talbotype, the earliest negative process, together with the subsequent modifications of plain and waxed paper pictures. Next come the glass processes with albumen, and, later still, Archer's great discovery of the value of collodion as the vehicle in which to carry the silver image. It was this introduction which did more to render photography practical than all the preceding processes, and the year 1851 may be looked upon as marking the birth of popular commercial photography. Examples of the modification of the collodion process, known respectively as "ambrotype" and "ferrotype," are shown, and we then pass on to the earlier attempts to produce "preserved" or "dry" plates. One of the earliest of the processes coming more correctly under the former title is that of Spiller and Crookes, in which the layer of sensitive collodion was retained in a moist condition for periods of from three to twenty-one days, by the application of hygroscopic or deliquescent substances. Dry plate processes are scantily represented by a few examples of the collodio-albumen process, the oldest and, in many respects, one of the best of its class.

As showing the degree of perfection to which the collodion process was brought at a very early date, attention may be directed to the instantaneous views of England and Blanchard, taken from 1855 to 1860.

Turning to printing processes, we find little variety, the earlier specimens consisting almost wholly of silver prints on plain paper, and a frame of prints in various metals, dating back to 1839–42. Photolithographic reproductions by Bullock, and examples of the photo-galvanographic and surface block processes of Paul Pretsch, produced between 1856 and 1860, complete the record of printing processes previous to 1862. Early specimens of processes of later date are included in this collection, some of which, in their perfected forms, will be noticed—as the carbon and Woodburytype and platinotype methods. The aniline process of W. Willis, sen., now superseded and almost forgotten, is also represented.

Amongst the miscellaneous examples of apparatus are many which are interesting from an antiquarian and historical point of view, no less than from the contrast they present to more modern instruments. Old Daguerreotype apparatus, and ancient cameras with a curious old world look, contrast oddly with the adjacent exhibits of modern cabinet work, while the optical instruments of the past present an even more remarkable difference. Amongst these are the early specimen of the "fluid lens" of Archer, the "panoramic" lens of Sutton, which is also a water lens, *i.e.*, a lens in which the correction is secured by a combination of glass of suitable curves, enclosing

water or other fluid of a different refractive power. The most interesting object in this class is, however, undoubtedly a lens constructed by Andrew Ross in 1841, which claims to be the first compound lens ever made for photographic purposes. Archer's first photographic camera, and the earliest silver bath employed in his own practice, are relics of merely antiquarian interest; and a curious old adjustable diaphragm of the date of 1851 shows how closely, in some cases, our modern apparatus follows the earliest lines. A collection of portraits of the fathers of photography is worthy of mention, and deserves to be reproduced in a more permanent form before the evanescent images have entirely disappeared.

The Photographic Society's collection forms a condensed summary of the progress of photography anterior and up to the Exhibition of 1862, from which period it will be necessary to trace the story elsewhere. At that time the collodion negative process and albumenised silver prints held full sway; the Daguerreotype process had nearly disappeared, and the glass positive was rapidly following the example; the "carte mania" was at its height, and the comparatively cheap *carte-de-visite* was surely supplanting its rivals in popularity, The greater facilities afforded by the collodion process had drawn a large number of landscape photographers into the field both professional and amateur, the former of whom adhered almost entirely to the wet collodion process, the latter, to a great extent, preferring to replace the old waxed paper processes by one or other of the dry preservative processes. It is matter for regret that so few specimens of the work of these processes subsequent to 1862 are on view, since results of the highest technical excellence were attainable, though at the cost of a considerable amount of trouble, as compared with later methods.

In 1861, Major Russell had introduced his tannin process, in which a glass plate, prepared with bromo-iodised collodion, was sensitised in a solution of silver nitrate in the ordinary manner, washed, in order to remove all traces of the soluble silver salt, and after treatment with a solution of tannin, finally dried, in which condition it retained its sensitiveness for a very considerable time. Later, the process was improved by the substitution of a plain bromised collodion for the bromo-iodised hitherto employed, by which means a greatly enhanced sensitiveness was gained. This substitution of bromide alone for bromo-iodide formed the starting point from which the first step in the direction of improvement was made. The preparation of the dry plates by the bath process was tedious, and occupied a considerable length of time in consequence of the numerous washings it was necessary for the film to undergo. So far back as 1860 the attempts had been made by Gaudin, in Paris, and Captain Dixon, in England, to dispense with the nitrate of silver bath, by forming iodide of silver in the collodion itself, and, subsequently, Liesegang worked in the same direction. But all these failed in securing a sufficiently fine suspension of the particles of silver iodide, unless by the aid of such an excess of soluble iodide that the films were too insensitive for practical use.

In 1864, Sayce and Bolton conceived the idea of substituting bromide for iodide of silver in a similar manner, and succeeded so well that in that year their process—subsequently called "collodio-bromide"—was published. This formed the first practical "emulsion" process, and was the first step in the direction of modern dry plate improvements. The capabilities of the process from its very introduction are shown in the exhibit No. 2,254, which consists of some of the earliest negatives taken by Sayce in 1864 and 1865. Some of these in point of quality could scarcely be surpassed at the present day. In course of time the process was improved and greatly simplified, the improvements taking the form of increased sensitiveness, while in the way of simplification the necessity for washing each individual plate was dispensed with by removing all soluble matter from the emulsion in bulk. By this means, the preparation of the plates was reduced to the single operation of applying the emulsion to a clean plate of glass, and allowing it to dry.

The next advance consisted in the substitution of gelatine for collodion as the vehicle in which to suspend the sensitive silver salt. This was suggested by Dr. Maddox, and carried out in practice in 1871, the earliest results of this process being included in the collection of the Photographic Society. This process, though crude, and its earliest results imperfect, has been demonstrated to be a practical one; but more recent improvements have supplanted it. In 1873, Burgess attempted to introduce commercially a gelatine emulsion, but failed from imperfect knowledge of its physical requirements. Later in the same year, Kennett patented his method of preparing a sensitive "pellicle," consisting of gelatine and pure silver bromide; and about the same time Johnston showed how the useless soluble constituents of a gelatine emulsion might be removed by washing. From that time the gelatino-bromide process became a workable one, but it was not until Bennett, in 1878, startled the world by showing the wonderful sensitiveness attainable with gelatine emulsion that it secured any great share of favour. Bennett's process of "prolonged emulsification" involved no new principle, nor probably did the resulting emulsion excel in sensitiveness others that had been previously made by different means. The secret of the apparent increase of sensitiveness lay rather in the extra precautions adopted to secure the already existent but unsuspected sensibility, and the marvellous results exhibited by Bennett at once attracted the attention of the profession, who were not slow in availing themselves of the new facilities thus afforded them, and in a very short time gelatine dry plates had come into general use.

Two remarkable examples of the exquisite sensitiveness of these plates, as compared with wet collodion, are found in the exhibits of E. Dunmore and Boldireff,

of St. Petersburg, the one being a view taken by moonl e other a series of pictures taken by artificial light, and evidently with extremely brief exposures. Dr. Huggins's photographs of star spectra form another instance of the opening up of an entirely new field of scientific research hitherto impossible, and many others could be instanced, such as the admirable photographs of yachts shown by the Paget Prize Dry-plate Company.

Before leaving the subject of negative processes, the replacement of glass by paper or other lighter and less fragile material should be mentioned. In this direction Warnerke has worked for years, and has recently considerably improved his process of preparation, by means of which the natural grain of the paper-support is hidden or masked. The Eastman Dry-plate and Film Company, of Rochester, New York, have also made great improvements, not only in the preparation of films, but also in the mechanical arrangements for exposing them. The "roller slide" of this company—a piece of apparatus by which a continuous band of tissue can be manipulated—is a marvel of constructive perfection, and though the principle is upwards of thirty years old, this instrument is the first to thoroughly fulfil requirements. Messrs. Morgan and Kidd (No. 2227) also exhibit specimens of paper negative work.

One other recent advance in negative work should be alluded to, namely, the system of "isochromatic" or "orthochromatic" photography, by which the colours of objects are rendered in monochrome in truer relation to their respective appearance to the eye. Many years since, Draper, Waterhouse, Carey, Lea, and Vogel pointed out that photographic films might be rendered more or less sensitive to certain colours by increasing or decreasing their power of absorbing rays of the particular colour; but it is only comparatively recently that Attout-Tailfer and Clayton in France, Vogel in Germany, Warnerke in England, and Ives in America, have availed themselves practically of the fact. Tailfer and Clayton, as well as Warnerke, exhibit interesting examples of their respective methods.

Turning now to the printing processes, the first in chronological order is the carbon process of Swan, known generally under the title of autotype. This is based on the discovery of Poitevin of the sensitiveness to light of a mixture of gelatine and bichromate of potash, or similar salt of chromium. Fargier, Pouncy, Blair, and others experimented with films of coloured gelatine rendered sensitive to light by means of chromic salts, and which, after exposure, were treated with warm water to dissolve the portions unacted upon, leaving a picture in insoluble gelatine attached to the paper or other support. The chief difficulty experienced was in obtaining half-tone, since upon exposure to light under a negative, the surface of the gelatine layer was rendered insoluble, and so imprisoned beneath it that portion which remained soluble; consequently, except for black and white subjects, the process was long impracticable. In 1864, however, J. W. Swan patented a practicable method by which such a layer—bichromated gelatine—could, after exposure to light, be developed from the back or under side; this was effected by cementing the "tissue" temporarily, after exposure, to a plate of glass or metal, and by means of hot water dissolving away the under layer of soluble gelatine, and with it the original support. The resulting picture could be allowed to remain upon the surface on which it was developed, or transferred to a second sheet of paper. Subsequent improvements by Johnson, Sawyer, and others, gradually brought the process to its present high degree of perfection, as shown in the exhibits in Groups XXVI. and XXIX.

In connection with this process, an interesting exhibit by E. W. Foxlee (No. 2277), shows in a graphic form the effects of what has been termed the "continuating" action of light on carbon tissue. It was discovered that if insolated carbon tissue be kept in the dark for any length of time before development, the action of the light went on in the same manner as, though in a less degree than, if a longer exposure to light had been given; in fact, that light might be economised by storing the tissue away for a few hours before development. Conflicting opinions were expressed on the subject, some authorities denying *in toto* the existence of any such effect, until the careful experiments of Foxlee demonstrated that the presence of moisture was absolutely essential to its production, and that it was accelerated by heat. The value of these observations, from an industrial point of view, removing as they do a considerable amount of uncertainty, can scarcely be overrated.

The next process that comes under notice is that known as Woodburytype, and which was the joint invention—though unknown to one another at the time—of W. B. Woodbury and J. W. Swan. In September, 1864, the former of these patented "an improved method of producing or obtaining by the aid of photography surfaces in 'relievo' and 'intaglio' upon aluminous, vitreous, metallic, or other suitable materials." In the following July, the latter secured a patent for "improvements in the production of printing surfaces by photographic agency, and in obtaining prints therefrom," this being apparently the first mention of the method of printing, the production of the mould being the same, or nearly so, in both cases. A layer of bichromatised gelatine of sufficient thickness is prepared, and, after exposure to light under a negative, is developed upon a suitable support, as in the carbon or autotype process. The result will be a "mould" in gelatine in which the shadows of the original stand in relief, while the high lights form depressions. From this mould a reverse is taken, either by electrotype or by pressing it into a sheet of soft metal, and this forms the printing surface. The ink consists of coloured gelatine, a small quantity of which is poured on to the "intaglio," previously

rubbed with an oily rag, a sheet of paper superposed, and the platen of a suitable press brought down, by which the superfluous ink is squeezed out, leaving a cast of coloured gelatine in the hollows of the intaglio. This adheres to the paper, and when dry, forms a picture in perfect half-tone. The process has been brought to a high degree of perfection by the Woodbury Permanent Photographic Printing Company, at whose stall, No. 2,260, examples of the various applications of the process are shown.

A simplification of the mode of preparing the printing mould is shown by Messrs. Woodbury, Treadaway, and Co., No. 2,258, in which the gelatine relief itself forms the printing surface, being "faced" with tinfoil in order to prepare it to receive the ink. This process, to which the name "Stannotype" is given, is useful for small numbers, but does not offer the same facilities for large production that the older process does. The printing is identical with the "Woodbury" method.

Another valuable addition to the list of printing methods is Willis's platinotype process, which is demonstrated by the Platinotype Company, at their stall No. 2,261. In this process, the picture is composed of the metallic platinum in a fine state of division, in consequence of which an image of almost absolute permanence is secured, the most powerful reagents, with the exception of *aqua regia*, having no action on it. Paper is prepared with a solution containing ferric oxalate and a platinum salt; upon exposure to light, the ferric salt becomes reduced to the ferrous state, ferrous oxalate being a powerful deducing agent in connection with metallic salts. An image is formed in insoluble ferrous oxalate, which so long as it remains in that state, exerts no effect upon the platinum salt in contact with it; but the instant the print is wetted with a hot solution of potassium oxalate, which is a solvent of the ferrous salt, the latter acts upon the platinum salt, and reduces it *in situ* to the metallic state, forming a rich black image of great beauty. Amongst the specimens exhibited by the company, a number of reproductions of works of art, by Mr. J. Thomson, show the suitability of the process in the rendering of the most exquisitely delicate subjects.

The newest departure in printing consists in the recent introduction of gelatine-chloride of silver paper, or paper prepared with an emulsion of chloride of silver in gelatine. Developed with ferrous oxalate or citrate, or with Mr. Arnold Spiller's hydroxylamine, it is capable of giving results scarcely distinguishable from albumenised silver prints and with but a few seconds exposure to light. Very fine examples are shown by Marion and Co., Warnerke, and Morgan and Kidd, but the process is still on its trial.

A. L. Henderson (No. 2,229) and Count Ostrorog Walery (No. 2,265) exhibit fine specimens of ceramic work, one of the most beautiful and permanent of photographic processes, the picture being burnt in upon a suitable enamel surface.

Of photo-mechanical printing processes in Group XXVI., there is a good and representative show in every branch except photo-gravure, which is conspicuous by its absence. Dallas, at stall No. 2,023, exhibits specimens of Dallastype and Dallastint, modifications of the photo-galvanographic process, worked formerly by Pretsch and himself. The Meisenbach Company show examples of their surface blocks for printing with type, in which an artificial half-tone is secured by breaking up the gradation by means of a series of dots or lines. A novel feature in connection with this style of process is found in the American section, where Ives, of Philadelphia, exhibits the latest development of the surface block process. In this a swelled gelatine relief is first produced from the photographic negative, and a cast in plaster taken from it. A sheet of rubber, the surface of which consists of a series of minute pyramidal projections, is inked and pressed into the plaster cast, and from this last an impression is taken, which is transferred to zinc to form a "resist" in the etching process. Sprague and Co. exhibit the working of their process of photo-lithography, in which the "grain" is produced by chemical means upon a gelatine surface, from which a transfer is made on to an ordinary stone.

The collection of apparatus, though complete in its way, and comprising all that is new, is somewhat disappointing, since the different exhibits present a sameness which destroys the general effect. The cabinet work in general is of considerable excellence, notably the exhibits of Hare, Rouch, Sands and Hunter, Marion and Co., and Collins, but there is little that calls for special notice. The same may be said in every department of the mechanical portion of the collection; while a vast amount of ingenuity and inventive power have been brought into play to meet the requirements of photography, there is nothing amongst the results that can be singled out as possessing super-excellence.

It would not be right to close this brief notice without calling attention to Mr. A. A. Common's remarkable examples of astro-photography, in the production of which the marvellous facilities afforded by modern processes have been supplemented by an unusual degree of perseverance and manipulative skill. Professor Hartley's labours, in photographing on an extensive scale the spectra of various metals, form another instance of valuable work performed in connection with a most difficult branch of science. The exhibits of these two gentlemen deserve most careful study.

The number of visitors to the Exhibition for the week ending Tuesday, 8th September, was 130,070. Total since the opening, 2,766,844.

THE number of tons of freight transported on American railroads in 1884 equalled 390,074,749, against 400,453,439 tons in 1883, the rate of decrease being about 2½ per cent. The value of the tonnage moved in 1884, estimating its value at 25 dols. the ton, equalled 9,751,868,725 dols.

AGRICULTURE IN SMYRNA.

The province of Smyrna, officially known as the villages of Aidin, extends over 35,500 square miles of territory. It has a sea coast line of 250 miles, and is both a maritime and agricultural province, and most eligibly situated in a commercial point of view. Its harbours are spacious and safe, and its rivers drain and irrigate fertile valleys. Its population, which has been considerably augmented by refugees from the despoiled European provinces of the Turkish Empire, amounts to about one million, or less than thirty inhabitants to the square mile. About 90 per cent. of the rural population is Moslem. In Smyrna the Greek population outnumbers all others, the Turks forming less than one-third of its inhabitants. Consul Stevens states that the tillers of the soil are sober, peaceful, and industrious. The lands are divided into *chiftliks*, or large farms, owned by the wealthy classes, and into small peasant proprietorships. The large estates are usually worked, as in the southern countries of Europe, by the peasantry on the half-profit system, the proprietor giving the use of the land, also the seed, and paying half the expense of reaping, harrowing, and weeding. In the more sparsely populated districts of the province, a system of leasing the land prevails, but the peasants prefer the half-profit system, as under it no capital is required, and the gleanings of the cereal crops, often as much as 8 per cent., and usually gathered by their wives and children, belong to them exclusively. The land surface is divided into mountain, hill, plain, and valley. The soil is good on the hills and plains, while along the valleys of the Hermus, Meander, and Cayster, it is exceedingly productive. The rivers flow through wide valleys skirted on either side by lofty mountain chains. The climate is mild in the valleys and cool on the mountains. The plains and valleys produce corn, cotton, oats, poppy, hemp, sesame, madder root, liquorice root, figs, grapes, and olives. In the highlands, in addition to corn and fruits, the staple product is valonia, of which not less than two million cwts. are exported annually. The land is measured by doonooms, the doonoom being equivalent to about three quarters of an acre, and its value in and around cities, as compared with the interior districts, is proportionally higher than in probably any other country. This is occasioned by the absence of personal security, the exactions of tithe officials, and the lack of any safe means of investment. It is estimated that the average price of arable land in densely populated districts is about thirty shillings a doonoom, while in thinly populated districts it is about five shillings. The legal direct taxes upon the rural lands of every kind are two-fold; first, one-tenth of all produce grown whether in the ground or on the trees; and secondly, four per mille is levied annually on the estimated value of the land and farm buildings. Urban house property is taxed eight per mille per annum on its estimated value. Rural property in Turkey belongs in great measure to the crown; its sales are made with these provisos:—At every transfer a tax of 5 per cent. on the purchase money is levied by the Government, while the inheritance is limited to eight degrees of consanguinity—first, children of both sexes; second, grandchildren of both sexes; third, to father and mother; fourth, to brother and half brother by the same father; fifth, to sisters and half-sisters by the same father; sixth, to brothers by the same mother; seventh, to sisters by the same mother; eighth, to the surviving husband and surviving wife. If no heirs comprised in these eight degrees of relationship exist, the land returns to the crown; but after the acquisition of any such crown lands, if the owner plants npon them a vineyard, vegetable garden, orchard, or olive grove, or constructs buildings thereon, all such superficical property becomes freehold, and may be inherited by the most distant relations. Owing to the paucity of population when compared with the extent of arable land, and to the fact that, except for gardens, cotton and tobacco fields, fertilising substances are not used, the land is allowed to remain fallow every third year. Thus a field with a summer crop, such as Indian corn, millet, sesame, beans, vetches, &c., is sown again the following autumn with wheat, barley, or horse beans, these being the winter crops. The third year it is not planted. The agricultural implements in general use are of the most primitive style and make. Oxen are used for ploughing and threshing; the yoke is a long straight stick, usually fastened to the horns. The plough is simply a triangular block of hard wood, with an iron cap as the point, one point in front, to which the oxen are fastened, and one behind it to guide it. The other implements are the harrow, rake, sickle, spade, pickaxe, sieve, and low-wheeled bullock cart. The ploughing is about four inches deep, with a space between each furrow of twelve inches or more. Irrigation is confined to vegetable gardens, although there is seldom any rainfall from May to October. With such methods of cultivation, barley and wheat yield about twelvefold, beans from twenty to twenty-five, millet and maize from twenty-five to thirty-five. The threshing of cereals is performed by horses and bullocks, beans and sesame by stick or flail. The straw, after threshing, is cut up and used as fodder for cattle. As a rule the peasantry do not plant vegetables, hence gardening forms a separate industry in the rural districts as well as in the cities. The wants of the peasantry are few. Bread, vegetables prepared with oil, milk, *petmez* (a syrup extracted from the black grape), form their principal food. Meat and rice are only occasional luxuries with them. They live in tents or cabins, and dress cheaply, although their clothing and linen are of foreign manufacture. The peasantry have a source of income in the breeding of cattle. Pasturage costs nothing, and fodder is required for only a short season; the only tax they have to pay is for sheep, goats, and pigs—for the former about 2s. 8d., and for the latter 1s. 9d. per head annually.

FISHERIES OF TASMANIA.

From the report of the Commissioners appointed by the Government of Tasmania to inquire into the condition of the fisheries of that colony, it appears that, including the successfully acclimatised European fish, there are found in Tasmanian waters 188 different species of known sea and river fish, of which about one-third are regarded as good edible fish. Of the latter, about 20 species are found in sufficient numbers to afford a regular supply for the market. One of the most highly prized among these, both on account of its size and flavour, is the "trumpeter," which is captured at a depth of from 10 to 80 fathoms, and sometimes attains a weight of 60 lbs. Tasmanian fishermen have hitherto depended principally for large returns upon the king fish, of which, however, owing to its migratory habits, the supply is very fluctuating. In 1874-5, it appeared in such vast numbers that the fish were actually sold for manure. In 1881 the quantity exported was merely nominal. Shoals of sprats, anchovies, and mackerel periodically visit the Tasmanian waters, but in the absence of the proper appliances for their capture and preservation, these large stores of wealth have hitherto remained unutilised. Among the crustaceans the most important, commercially, is the crayfish, which is found in great numbers, especially on the eastern coasts, but which, notwithstanding its present abundance, is threatened with total extinction, owing to its wholesale capture, irrespective of size or condition. Referring to the Tasmanian oyster fisheries, which, twenty years ago, were of great commercial importance, the Commissioners remark :—"It is astounding to contemplate the fact that the quantity then brought to market in one year would now, at current prices, realise a sum of £93,125, that is, a sum more than the equivalent of the value of the last three years' export of grain, hay, flour, and bran from Tasmania; and when we consider that the only natural beds which may be profitably worked are now to be found only in one district, viz., the vicinity of Spring Bay, and that the total yield does not amount to more than one hundred thousand oysters a-year, it is humiliating to confess that the lesson in oyster culture given to the world by France many years ago, should in this colony be so thoroughly disregarded." The Commissioners report that the efforts made from time to time to acclimatise certain species of the salmonidæ have been fairly successful. This is especially true of the salmon trout and the large brown trout. With regard to the successful introduction of the true salmon, the report of the Commissioners leaves the question in some doubt, but they give it as their opinion that the successful acclimatisation of this fish from the ova already received is only a matter of time. Referring to the development of the fishing industry, the Commissioners call attention to the desirability of extending the market for fresh fish, and urge the adoption of improved appliances for the capture and preservation of both the permanent and migrating fish with a view to foreign exportation, and recommend that, for the better preservation of the fisheries of the colony, the general administration of all matters relating to the sea and inland fisheries should be vested in a central Board acting under the direction of the Governor in Council, and that a competent inspector be appointed to enforce the regulations adopted from time to time by the Board.

WINE GROWING IN AUSTRIA-HUNGARY.

Consul Weaver says that the methods of pruning the vine in the wine-growing districts of Austria differ slightly, and vary also in regard to the kind of grapes in the same part of the country. In most districts, especially those to the south of Vienna, in the neighbourhood of Vöslan, where the best red wines of Austria are produced, the branches are cut down to one or two eyes, and on each vigorous vine five to six branches are left. At a longer cut the vines usually grown in this country, the Portuguese and Blue French, bear grapes superabundantly, producing an inferior quality, and resulting in the exhaustion of the vines in a few years. A longer cut is only customary in regard to the Blue Burgundy and the St. Laurent vines, which, however, are not very extensively cultivated, at which operation either four eyes are left on each of twelve branches, or on a longer grape-bearing branch, five to seven eyes, while the remaining branches are cut down to one or two eyes. During the subsequent year the old grape-bearing branch is cut off, and the strongest of the branches produced from the eyes of those cut down in the preceding year will be employed as the grape-bearing ones. The soil in the vicinity of Vöslan and Gumpoldskirchen, where the most excellent white wines are produced, consists of a light flat and loamy ground, the subsoil of which near the mountains consists of a calcareous rock, and on the plains of alluvial gravel. The fine wines grow on the slopes only. The valleys are left to the cultivation of other products. In the plains, wines of inferior quality are produced, but in larger quantities than on the hills, the produce, however, is very uncertain, on account of the night frosts in spring, which do great damage on the plains, while the slopes are spared. The soil in nearly all the vineyards in Austria is worked three times a year with the hoe. First, in spring, after the April cutting; second, after the binding up and weeding at the end of June; and thirdly at the end of July or early part of August. In Vöslan and vicinity, the soil is worked a fourth time, at the end of the vintage in October or November, by digging the soil as deep as possible in order to keep it loose during the winter. This has an extraordinary influence on the growth of the vine, and renders the working in spring much more

easy. Artificial irrigation is nowhere employed in Lower Austria in the cultivation of the vine. The average wine production of Austria-Hungary during the last five years amounted to about 180,000,000 gallons, of which 68,000,000 gallons were produced in Austria, and 112,000,000 gallons in Hungary. The average was estimated by the Department of Agriculture at Vienna and Budapesth at about ten florins the hectolitre, or about ninepence per gallon, a price very much below the commercial value of even the most ordinary wines. In Austria, the chief producing districts are Dalmatia, Lower Austria, the Northern Tyrol, Styria, and Istria. The character of the Austrian red wines is lighter and cruder than those of France, while the white wines, in respect to quality, are inferior to those of the Rhine, but possess a larger quantity of alcohol than those of either the Rhine or the Moselle. Among the finest and most celebrated Austrian wines is the Vöslaner, while of the Hungarian, the Tokay and Paluggay are the most noted.

LIVE STOCK IN EUROPE.

The United States Consul at Copenhagen, writing on the subject of the live stock in Europe, says that the number of horned cattle throughout Europe is estimated at about 92,000,000, of horses 36,000,000, sheep 200,000,000, and of swine about 46,000,000. Of the European States, the Scandinavian countries and Servia stand in a prominently favourable position as regards the relative amount of their live stock to the inhabitants, Denmark ranking first on the list with 735 head of horned cattle per 1,000 inhabitants, next Servia with 609, then Norway with 562, and, lastly, Sweden with 483. France may be taken as representing the European average, whilst below the average come Great Britain, Spain, Belgium, Greece, Portugal, and Italy. Of sheep, Servia has relatively the largest number, namely, 2,200 head for 1,000 inhabitants, and Greece with 1,496. Spain, Roumania, Great Britain, and Norway rank as above the European average, Denmark about the average with 777 head, and all the other countries below the average, the lowest in rank being Holland, Switzerland, and Belgium, with 121 head. Of swine, Servia has relatively also the largest number, namely, 1,062 head, whilst Spain, which follows next, has only 272, then Denmark with 263; Portugal, Austria, Roumania, and Germany being all above the average, France about the average, and the remaining countries below, the lowest in rank being Sweden, Holland, Italy, and Norway, with only 56 head. In an examination of the total numbers of live stock in the different countries, it will be found that Russia has the decided superiority, taking all classes of animals together. This country, including Poland and Finland, in the year 1876, possessed 25,000,000 head of horned cattle, 45,000,000 sheep, 10,000,000 swine, and 17,000,000 horses. The increase during the last twenty years has been greatest in sheep—about 20 per cent.; whereas the increase of horned cattle and swine has only been about 4 per cent.; and horses have remained stationary. Next to Russia, Germany has the largest number of horned cattle—about 15,000,000, of sheep 25,000,000, of swine 7,000,000, and of horses 3,000,000. In Prussia there has been, of late years, a considerable increase in all classes of animals; in Saxony and Baden it has been stationary; while in Bavaria, Wurtemburg, Hesse, and Oldenburg, there has been a falling off. Austria, with Hungary, ranks third on the list, so far as horned cattle and swine are concerned, respectively with 12,000,000 and 7,000,000; in the second rank as regards horses, namely 3,000,000, but only in the sixth rank as regards sheep, with 20,000,000. After Austria, France has the next largest number of horned cattle, about 11,000,000 head, while it only occupies the fourth place for sheep and swine, namely, 24,000,000 and 5,000,000, and 2,000,000 horses. From 1850 to 1872 there was a considerable falling off in horned cattle in France, but in later years there has been a steady improvement. Great Britain follows next in regard to horned cattle, namely, with 9,000,000 head; but, in respect to sheep, stands second on the list with 32,000,000; she takes the fourth rank in respect to horses, viz., with 2,750,000, but for swine only the sixth rank, with 4,000,000. Live stock in Great Britain has fallen off very considerably of late years; for example, from 1874 to 1880 there was a decrease of 500,000 head of cattle, 4,000,000 sheep, and 750,000 swine. Italy ranks last with respect to horned cattle, with 3,500,000 head, 1,000,000 horses, 9,000,000 sheep, and 3,750,000 swine. Of late years there has been a falling off in the number of horned cattle, but sheep show an increase. In Holland the absolute number of live stock may be given as 1,500,000 head of cattle, 1,000,000 sheep, 500,000 swine, and 300,000 horses. The cattle interest in this country is of considerably more importance than the culture of cereals, about 40 per cent. of the land area being devoted to meadow and grass land. Denmark, in the cattle census of 1881, was stated to possess about 347,500 horses, 1,470,000 head of horned cattle, 1,548,600 sheep and lambs, and 527,000 swine. These figures, as compared with the previous census of 1876, show a very considerable increase in horned cattle and swine, while there is a diminution in the number of horses to the extent of 5,000, and in sheep of 170,000. In Norway, where the cattle interest is of more importance than cereal culture, the number of horned cattle is given at about 1,000,000 head, sheep at about 1,700,000, but of swine not more than about 100,000. Lastly, Sweden appears with 2,000,000 head of horned cattle, 1,500,000 sheep, 500,000 horses, and 450,000 swine. Taking the extra European countries, the United States comes first with its enormous and steadily increasing amount of live stock, which, notwithstanding the large annual increase of population

from natural causes as well as from the great tide of emigration annually pouring into the country, has been fully able to keep pace with its relative position to the population. According to the latest returns, the number of horned cattle in 1882 amounted to 41,000,000; of sheep and lambs, 49,000,000; horses, 11,000,000; and swine, 43,000,000. From Canada there are no later census returns than those of 1871, when the numbers given were 2,700,000 head of horned cattle, about 3,000,000 sheep, and 1,500,000 swine. South America has relatively a larger number of animals even than the United States, especially the La Plata States are noted for their enormous hordes. Statistics place the number of horned cattle at 19,500,000 head, with 70,000,000 sheep, and about 500,000 swine. In the Pampas the horned cattle are estimated at 30,000,000. In Algeria, the number of live stock in 1879 was stated as 1,200,000 head of horned cattle, and about 9,000,000 sheep. As regards Australia, the stock of animals in these colonies has received a very great increase during the last ten years. In the census of 1878, horned cattle are stated as 7,400,000, as compared with 4,700,000 in 1876; sheep, 61,000,000, against 51,000,000; and swine, 815,000, against 695,000. The proportion of live stock to every 1,000 inhabitants is very large, being as much as 2,800 head for horned cattle, 23,400 for sheep, and 310 for swine.

WINE MAKING IN THE PROVINCE OF AREZZO.

Consul-General Colnaghi, in his report on the topography, climate, industries, and agriculture of the Tuscan province of Arezzo, says that vines are cultivated along the sides of the ditches or drains which run by the fields. The land is prepared for vines by digging a trench in January or February, about three feet deep and three feet broad. In the following October, or in March and April of the succeeding year, slips with young roots or layers are planted, the trench being filled in with earth at the same time. The lowest and wettest ground is drained with stones, brushwood, and earthenware pipes. At a distance of every seven yards, a maple is planted, round which from six to eight layers are placed. For three years the ground is well dug and manured, and the young plants undergo a general pruning, both green and dry, always bearing in view the stem which is to form the plant, and which is generally finally selected the third or fourth year, according to its development. The old vines attached or married to the maples are systematically pruned, leaving on each, according to its strength, two, three, or even four pendant branches. Stable manure is generally used for the vines, and of late years *soveschi*, or mixture of lupines and ashes. At sowing time the furrow next the line of vines receives an extra supply of manure. The qualities of grapes cultivated are the *Malvagia* and *Albano*, white; and the *Canaijolo*, *Sangioiese* or *Calabrese*, *Gorgottesco*, and *Lambrusco*, black grapes. The *Lambrusco* is used to give colour to the wine. The vintage is held in the beginning of October, the white, black, and damaged grapes being first separated. Division is made on the field between the landlord and the metayer, and the landlord's grapes are carried in open tubs to the wine floor, and they are then pressed in a machine press and transferred to vats or casks. In about a week, two or three days after the first fermentation has ceased, during which they are exposed to the air as much as possible, the must, which is still very turbid, is drawn off into casks. The lees are then pressed several times to extract the *stretto* or *premitura*, which is also put into casks, the mass is then returned to the vats, water is poured over it, and the *vinello* for domestic use is obtained. When this has been done, the lees, the grape stones being first separated, are given to the cattle, and occasionally the oil is extracted. The damaged or inferior grapes are treated separately. After being pressed and the must drawn off, they are pressed a second time, and the *stretto* and must are placed in casks together, to prevent fermentation taking place in contact with the bad grape stones. The white wine thus obtained is termed *vergine*. The red wine is not made with black grapes only, but with an admixture of one-third white grapes; about one-fifth of the stalks are removed to avoid a redundancy of tannin and tannic acid. After the wine has been left quiet for about a month in the cask, it undergoes the operation known under the name of *governo*, which is carried out in the following manner:—At the vintage a selection is made of the finest black grapes, which are laid on cane mats to dry. They are then stoned, taken off the stalks and placed in casks, where they undergo an imperfect fermentation, after which the must is drawn off, and must and lees together are distributed among the casks of new wine in the proportion of one pound to every two gallons. The wine by this means acquires a slightly biting taste, called *frizzante*, due to the development of carbonic acid, and is much sought after in Tuscany. It gains body and aroma, deepening in colour, while it becomes clearer. Wine that has undergone the *governo*, if kept too long, loses many of its good qualities, and frequently turns acid. In January and April, the wine intended to be sold in summer is drawn off into other casks, and that sold in winter is not racked, as it would lose the *frizzante* in the process. At every racking the casks are fumigated with woollen rags steeped in sulphur. Pumps are used to preserve the wine from contact with the air as it is being drawn off. The wine which is intended to be kept for more than a year does not undergo the *governo*, but, towards the end of December, is racked for the first time, and a second time in March, when it is clarified with white of egg and isinglass. In May, the wine is transferred to a fresh cask for the third time, after which it is

left quiet till October or till the following March. It is then put into flasks for about a year, after which it is bottled. The casks are well closed with cylinder stoppers, a little rectified spirit of the best quality being poured on the wine in the cylinder to keep off the air and prevent mould. The average quantity of wine produced is estimated at the rate of about eleven gallons per acre.

PIONEER PASSENGER RAILWAY.

Fifty-five years have elapsed since the opening of what may be regarded as the first passenger railway ever constructed in this or any other country. Although the Stockton and Darlington line was the first railway ever constructed in England, having been opened on the 27th of September, 1825, it was primarily intended and used for the transit of coal, lime, and bricks from the interior to the seaboard. It is true that, in the following month, a passenger coach was placed on the line, drawn by one horse, and performing one journey daily between the two towns, travelling at the rate of about nine miles an hour. The waggons containing coal and other merchandise were drawn by a locomotive built by George Stephenson, the maximum speed being from ten to twelve miles an hour. The 15th of September, 1830, will therefore be remembered, for all time, as the day on which travelling by steam power on a large scale was inaugurated, in the opening of the Liverpool and Manchester Railway, where the complete success of the locomotive steam-engine was accomplished; the "Northumbrian" engine, on that occasion, with the Duke of Wellington, and other distinguished visitors in the train, attaining a speed of thirty-six miles an hour. Following upon the opening of the Liverpool and Manchester line, the construction of railways in different parts of the country rapidly succeeded each other, and it is interesting to look at what has been accomplished in this branch of engineering during the last half-century, not only as regards our own country, but also in Europe and other foreign regions. Confining our notice to the United Kingdom, we find, according to the last official return, brought down to the close of the year 1884, that the authorised capital in respect of the lines now open for traffic was, at that period, £742,417,327, and the aggregate length of railways 17,512 miles, which will shortly be still further increased by the completion of the several new lines now in course of construction. The total outlay in the construction of the lines now open, down to the end of last year, was £628,276,016, and the estimated further expenditure during the present year is upwards of £12,000,000. What may be classed as the fifteen leading lines, which have from time to time absorbed so many of the smaller railways into their respective systems, represent £644,246,356 of the total capital of the various lines open, leaving £78,718,559 as the capital the remaining lesser lines. The fifteen leading lines, as above named, have an aggregate length of 13,475 miles, an analysis showing that, as respects mileage, the Great Western Company stands at the head, while the London and North-Western Company has the largest amount of capital, being £101,771,907, with a mileage 1,794 miles in length. As regards capital, the Midland Company is next in amount with £76,549,267, and 1,270 miles of railway. The capital of the Great Western Company is £75,108,424, and its length of railway 2,301 miles. Then follow the North-Eastern, with a capital of £57,650,895, and 1,536 miles of railway; the Great Eastern, capital £41,087,103, and 919 miles of railway; the Caledonian, capital £36,324,700, and 772 miles; the Great Northern, capital £35,380,050, and 949 miles; Lancashire and Yorkshire, capital £41,852,949, and 496 miles; North British, capital £33,576,211, and 984 miles; Manchester, Sheffield, and Lincolnshire, capital £27,248,627, and 291 miles; Londondon, Chatham, and Dover, capital £25,634,008, and 176 miles; London and Brighton, capital £23,768,899, and 455 miles; South-Eastern, capital £21,915,824, and 385 miles; London and South-Western, capital £29,455,931, and 818 miles; and Glasgow and South-Western, capital £13,921,570, and 330 miles.—*The Times.*

ROPE RAILWAY AT GENOA.

The construction of a rope railway on the Agudio system, at Genoa, from Balzaneto to the Madona della Guardia, has been sanctioned by the Minister of Public Works. One of the most important features in this scheme, and in which it differs from the line now in operation, on the Agudio plan, from Turin to the Superga,* is that no stationary engine will be required, as Mr. Agudio, the engineer, intends utilising the power of the same locomotive that will be employed for bringing the train from Balzaneto to the foot of the incline to the Sanctuary, a vertical height of 700 metres (2,296 feet). This power will be transmitted, as is the case with the Superga line, by an endless wire rope, driven at a high speed, to a specially constructed apparatus, or "*locomotore*," which receives the energy thus conveyed to it, and utilises it for the direct haulage of the train. In this way, one of the principal drawbacks in the application of this system will be avoided, as the traffic on such lines is very variable, and the expense of keeping a stationary engine of at least 250 horsepower, forms a serious item in the working expenses, and especially so on week days or during the winter months, when the traffic must be small. The locomotive, which will weigh about 26 tons, will, after having brought the train from Genoa to the foot of the incline, be disconnected, and taken on to a

* Described *Journal*, vol. xxxii., p. 1020.

siding, where, by a suitable arrangement, it will be lifted off the rails, and its driving wheels will bear on and be supported by other wheels revolving in fixed bearings placed below the level of the rails. The motion of the driving wheels of the engine will be thus communicated to the wheels below, which, being connected by suitable gearing with the pullies for driving the rope, will thus transmit the energy developed by the locomotive to the "*locomotore*," or driving car attached to the train, and use it for hauling up the train.

Under these conditions, the locomotive will, whilst working as a fixed engine, no longer have a large proportion of its power absorbed in drawing its own dead weight, and, therefore, if only 150 horse-power are utilised whilst drawing the train, consisting of three passenger carriages, containing 150 persons, its useful power will easily be increased to 250 horse-power when it no longer has a dead weight of 26 tons to drag.

THE COTTON INDUSTRY OF ITALY.

A detailed statement by Signor Crespi, in the *Wochenschrift für Spinnerei und Weberei*, shows the increasing importance of cotton spinning in Italy. Imports of yarn have fallen in 1884 to 6,300 tons, as against 7,400 tons in 1883, and the number of spindles has increased during the last seven years from 700,000 to 1,200,000. With the exception of a newly erected factory at Lucca, and establishments at Naples and Salerno, all the spinning mills are in Upper Italy (Lombardy, Piedmont, Liguria, and Venetia). During the period referred to, the quality of the yarn produced has considerably improved, the older machinery having almost completely disappeared, and being now replaced by the best models of the present day. Night work has become more general. The workpeople have acquired experience, and inland transport rates (particularly fcr Indian cotton) have been reduced, so that various causes have been operative in bringing about this new development of Italian industry.

In the coarser numbers of yarn the production has now attained considerable importance, while the spinning on a large scale of fine numbers remains still to be achieved. Bleached yarns alone were imported in 1884 upon the same scale as 1883, but a bleaching establishment is now being organised at Brembate in order to develop this branch of production.

Signor Crespi asserts that, notwithstanding the degree of progress reached by Italian spinners, they are prevented by circumstances of a special character (regarding the cost of erecting factories, &c.) from working as economically as their English and Swiss rivals. Their commercial success he attributes in no small degree to their skill in buying their supplies of the raw material, this merit being rather of a mercantile and speculative than of an industrial character.

The extension of the weaving branch has been carried out with an activity fully equal to that shown in the development of the spinning industry. Previous to 1870, there were only a few hundred power-looms in Italy, but at present the number exceeds 25,000. A diminution in the importance of the hand-weaving industry has taken place, as might be expected, but the net result is a marked development production. of The manufacture of tissues in various colours has acquired relative importance, these goods being exported to South America. There are only three cotton-printing establishments, the production of which is relatively unimportant. The total import of cotton goods represents more than a quarter of the entire consumption, but from the actual progressive condition of Italian industry, Signor Crespi considers that, ere long, its production will fully supply the wants of the home market, and possibly allow of an increased export trade being organised. The dyeing and finishing industries are in a backward condition, and it is in this direction that improvement is now specially called for, if Italy is to attain lasting importance as a cotton manufacturing nation.

PRIZE COMPETITION AT LILLE.

Amongst the prizes offered by the *Société Industrielle du Nord* for this year's competition are the following:—

Prize of 500 francs to the author of any work on pure or applied chemistry, the results of which are considered of sufficient importance from a practical point of view.

Prize of 500 francs, placed by M. Danel at the disposal of the administrative council, to be awarded to a work considered deserving of it.

Prize of 500 francs offered by M. Roussel (to which the Society will add a medal) to the author of a completely elaborated project as to the manufacture of artificial alizarine in the north of France.

A sum of 600 francs (offered by the members of the administrative council) will be devoted to prizes for competitions in Fnglish and German. These prizes will be given to the pupils and *employés* of the district who shall have given proof of practical acquaintance with the one or other of these languages.

Certificates to persons following the courses of spinning and weaving instruction established by the municipality.

Medals to two counting-house *employés* who can show long service with one of the members of the *Société Industrielle* residing in the north of France.

In addition to the above prizes, the Society reserves the power of recompensing any industrial progress realised in the north of France, and which

may not be specially referred to in the programme. The distribution of prizes will take place in January, 1886.

Correspondence.

PHILOSOPHICAL INSTRUMENTS AT THE INVENTIONS EXHIBITION.

Mr. Edmondson, in a letter inserted in your issue of September 11th, charges me with making a seriously misleading statement about his calculating machine, and under cover of his explanation, does my machine considerable injustice. As the matter is of great importance to me, I will ask your kind indulgence while I reply to his remarks.

In the third paragraph of Mr. Edmondson's letter he admits that he has springs in his machine to steady the number discs when the slide is lifted. Now any user of the arithmometer will bear me out in saying (1) that the lifting of the slide is not an occasional operation, as Mr. Edmondson suggests, but a constant and necessary one in every calculation for which the machine is likely to be used; (2) that the correctness of the results depends upon the fixity of the discs when the slide is lifted; (3) that the only object of the springs he uses is to attain that fixity. How can Mr. Edmondson, in the face of his own admission, and the facts I have stated, say, without misleading your readers, that "there are no springs in my machine upon which the fixity of the number discs depends when in operation. Such springs have been entirely eliminated."

Mr. Edmondson has given lectures on calculating machines, and he has professed to give a description of mine amongst others, and he ought therefore to know (1) that the springs to the number discs of my machine, although differently applied, are used to perform precisely the same work as his; (2) that, like his, they are useless when the slide is in gear, and indispensable when the slide is lifted; and (3) that, like his, they have nothing to do with the reckoning. It is, therefore, incorrect and misleading to state that "the correct action of all other arithmometers depends upon the springs which I have eliminated."

With regard to the vibration of my number disc springs, to which Mr. Edmondson alludes, I consider, after practical experiments extending over some years, that the arrangements producing them are necessary to hold the discs properly when the slide is lifted. I have already alluded to the importance of the discs being held properly, and I am quite willing to leave the question, whether Mr. Edmondson's method or the one I have adopted is likely to prove the most efficacious in practice, to any one having the most elementary knowledge of mechanical science.

I am quite correct in alluding to the springs which Mr. Edmondson has introduced as having lately been applied, because when the Inventions Exhibition opened he used, in place of the present springs, a piece of wire, worked in and out of the number discs to form a tension.

The two machines are exhibited at the Inventions Exhibition, and it will only be necessary for anyone interested in this correspondence to judge for himself by inspection whether I have made a single misleading statement.

S. TATE.

26, Gloucester-street, Clerkenwell, E.C.
September 14th, 1885.

Obituary.

COLONEL WILLIAM YOLLAND, R.E., C.B., died at Baddesley Vicarage, Atherstone, Warwickshire, on Friday, 4th inst. He was born in 1810, was admitted into the Royal Academy at Woolwich, where he obtained his commission in the Royal Engineers in 1828. He became lieutenant-colonel in 1855, and a brevet colonel in the army in 1858. After serving in Canada till 1835, he was employed successively on the Ordnance Survey at the Tower of London, at Southampton, Dublin, and Enniskillen. During this period he superintended the publication of astronomical observations, first those made with Ramsden's zenith sector, and afterwards with Airy's, the latter observations being for the purpose of determining the latitudes of various trigonometrical stations in Great Britain and Ireland. He also compiled an account of the measurement of the Loch Foyle base, which was made during the years 1827-29. In 1854, Colonel Yolland was appointed one of the Inspectors of Railways under the Board of Trade. In 1856, he was selected as the engineer member of the Commission appointed by the Secre- of State for War to consider the best mode of reorganising the system of training officers of the scientific corps, with the special intention of abolishing patronage, and opening the commissions in those corps to competition. Colonel Yolland was elected a Fellow of the Royal Society in 1859, and a member the Society of Arts in 1860.

COLONEL CHARLES RATCLIFF, who died last week, was one of the promoters of the first Reformatory Conference, held in Birmingham in 1851 With Lord Brougham and Mr. G. W. Hastings, M.P., he was also one of the originators of the Social Science Association, and he acted as a local honorary secretary at the first meeting of the association. He was elected a member of the Society of Arts in 1856, and in 1877 he served as a member of the Birmingham General Committee of the Domestic Economy Congress.

General Notes.

The Omnibuses and Tramways of Paris.—The total number of horses owned by the General Omnibus Company of Paris, at their various depôts, is 13,679; of these, 9,377 are employed for the omnibus service; 3,541 for the tramways; 586 for the omnibus service from the railway stations, and 175 at Versailles. This would give an average per vehicle, for the omnibuses, of 15 horses; 13·73 for each tram-car, and 14·19 for the service from the railway station.

Camphor in China.—Reporting on the trade of Tamsin, China, the Commissioner of Customs says that the trade in camphor is represented in the returns by such an insignificant figure, that there is great fear of its total extinction in the near future. The immediate cause of its rapid collapse may be traced to the eagerness of the Chinese to acquire, by all possible means, as much territory as possible. During the last three years, hills thickly wooded with camphor trees have been burned over by the Chinese, in order to compel the savages to withdraw. Destruction on so large a scale naturally tells on the camphor trade. Forests of camphor trees do still exist further inland, but the absence of all beaten tracks across the mountains render them difficult of access.

Economic Employment of Natural Gas.—Nearly all the ironworks at Pittsburgh, besides some forty iron firms within a radius of thirty miles, are now using the natural gas of the district, as are also most of the glass factories, distilleries, breweries, &c. This is creating an entire revolution in the labour market there. The output of iron and steel at Pittsburgh is about 750,000 tons per annum, and as it takes some fifty bushels of coal to make one ton of iron, it follows that at least 38,250,000 bushels of coal will be dispensed with in the yearly consumption, throwing out of employment an enormous number of miners, firemen, ashmen, roadmen, and other *employés* of the collieries. The cause of this great change being entirely one of nature's arrangements, renders it an impossibility for trade unions and labour agitators to deal with the matter.—*Nature*.

Fatal Accidents to Workmen.—The *Sprechsaal* calls attention to the fact that in Germany the number of preventible factory accidents forms a relatively large proportion of the total cases officially recorded. Thus, in the Dresden district, the rate was for last year 44·6 per cent.; out of which 29·8 per cent. arose from the carelessness or unskilfulness of the injured persons, 11·7 per cent. from their not using existing means of precaution, and 3·1 per cent. from the absence of these safeguards. In some industrial centres the proportion of avoidable mishaps was as high as 64 per cent. The gravity of the accidents would seem, however, to be in an inverse ratio to the industrial development of any given centre. Thus, in the agricultural district of Posen, the proportion of deaths to accidents was 55 per cent., while at Berlin it was 3 per cent., and at Chemnitz 1 per cent.

Line of Steamers between Genoa and Rome.—It is announced that a line of steamers will shortly commence running between Genoa and Rome. The first of these steamers, which are of 200 tons burden, called the *Corriere di Roma*, sailed from Newcastle, on the 25th August, for Genoa, and will shortly be followed by a second, the *Corriere di Genova*, now building at the same place. They are well fitted up, with accommodation for passengers. It is said that there will be a considerable reduction, both in fares and freights, on the present railway charges.

Electric Lighting in Italy.—The city of Palermo will shortly be lighted by electricity, and it is said that one of the principal firms there have arranged with the American Company, the International Electric Company, for this installation. The machinery will be shipped at New York by the *Gottardo*, one of the steamers of the Italian Navigation Company. The experiments recently made for lighting the tunnel at the Col di Tenda have been successful, and it has been decided to light it definitely by electricity. The Cruto incandescent lamp has been introduced in South America, and it is to be adopted in the lighting of several establishments at Montevideo. This lamp has been selected by the Municipality of Turin for the lighting of part of the city, and a public trial of the illumination of the arcades *viâ* Po was made by order of the authorities last month.

Artificial Stones for Lithography.—The *Patent Blatt* describes a process, introduced by M. Rosenthal, of Frankfort, for making artificial lithographic stones. The ingredients consist simply of cement. In the first place a sufficient quantity of finely ground cement is mixed with water, and allowed to harden in slabs either in the open air or in an oven. When the cement has set, these slabs are wetted and heated, until they crack in all directions; it is then reduced to a fine powder, and is well mixed with an equal quantity of fresh cement. This mixture is put in a dry state into strong cast iron moulds, and is subjected in them to a pressure of from 35 to 30 atmospheres. A sufficient quantity of water is then introduced on one side of the mould, and is drawn through the mass of dry powder by means of a pump connected with the opposite side; this water contains a certain quantity of extremely finely powdered cement, which is thus caused to penetrate throughout the mass, expelling at the same time the air and cementing it firmly together. The artificial stone is subjected to further pressure. In this manner slabs of the required size can be formed economically. Carbonate of lime may be substituted for cement, in which case the stones are of a lighter colour.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Proceedings of the Society.

CANTOR LECTURES.

CHEMISTRY OF PIGMENTS.

By J. M. Thomson, F.R.S.E., F.C.S.
Demonstrator of Chemistry at King's College, London.

Lecture II.—Delivered March 2, 1885.

In my first lecture I considered certain pigments yielding white, red, and yellow colours, describing to you shortly their methods of formation, and, in certain of them, the means by which their ordinary impurities might be detected. In this, my second lecture, we will consider some instances taken from the common green and blue pigments; and it is my wish, in the case of some of these substances, to go a little more fully into methods illustrating their examination and analysis.

Green Pigments.—Chrome Greens.—As I was speaking in my last lecture of the yellow pigments derived from chromium, I will commence my lecture to-night with the green pigments which are also obtained from compounds of that metal. You will recollect that, in speaking of the yellow pigments containing chromium, I spoke of the chromium being in the acid condition, as chromic acid combined with other metals, such as lead, barium, zinc, &c. The green pigments, however, derived from this metal, except in one or two cases, are all more or less oxides or hydrated oxides, which compounds yield us pigments varying very much in hue, according to the method adopted in procuring them. To show you how much the presence of water combined with these oxides, and the temperature at which the body is formed, may affect the colour, I will here precipitate a substance of this kind, according to the different conditions. For this purpose I use a salt of copper, which metal we shall find yields us various green colours through its compounds. Taking a solution of copper sulphate, and dividing it into two portions, I boil one portion over the lamp, and whilst this is warming, I add to the cold portion a solution of caustic potash. You see at once a light blue precipitate is formed, which is apparently perfectly stable in its colour. On filtering this body and drying, it is found on analysis to be a hydrated oxide of copper, represented by the formula $Cu(OH)_2$. Now taking the boiling solution of copper sulphate, and adding to that some warm potash solution, you see a totally different result, the precipitate in this case being of a dense brownish black colour. At the temperature of boiling water, 100° C., the water does not unite with the oxide, which is therefore precipitated as a black body of the composition CuO. This simple instance will, I think, show you how easily the substances may take different colours in their preparation.

The different greens which owe their colour to the chromium oxides, either hydrated or otherwise, are generally prepared by heating some volatile salt of chromium, by which process the chromium oxide remains behind; or by decomposing other more important salts with different reagents. Thus, by heating ammonium bichromate, the ammonia is driven off, and the chromium absorbing oxygen from the air, becomes converted into the oxide. The same decomposition takes place when mercury chromate or bichromate is decomposed by heat, which is done by placing this chromate in a retort, and raising the temperature. The mercury distils over, and may be collected in suitable vessels, whilst the chromium oxide is left behind as a brilliant green of considerable depth of colour. Bichromate of potassium may also be decomposed by hydrochloric acid in quantity just sufficient to combine with the potassium, when potassium chloride will be formed, and chromium oxide. Such a decomposition may also be carried out by adding sulphur to a boiling strong solution of the bichromate just mentioned, when a hydrated oxide of chromium is precipitated; this body must first be dried, and finally calcined at a moderate temperature. By fusing together the bichromate and sulphur, and, when cool, extracting with water the potassium sulphate formed in the reaction, the same green may be obtained. A

fine apple-green colour may be made, by treating the residue left in the retort after potassium bichromate has been treated with sulphuric acid, with boiling caustic potash or soda, the chromium oxide being formed. Prepared in this way, the substance has a beautiful green colour of considerable power. "Veridian" is another green of great brilliancy and permanency, also formed from chromium oxide, this body being in the hydrated condition. To form this green, potassium bichromate is decomposed by ammonium sulphate, in the presence of just sufficient warm water to render the mixing of the bodies possible. The material, on cooling, is broken in pieces and heated, for a short time, to a temperature not exceeding 200° C., when the water and ammonia pass off, leaving the hydrated chromium oxide. This powder must be thoroughly washed with water to remove potassium sulphate, but even with many washings the pigment is found still to contain traces of that body. It may also be prepared by calcining potassium bichromate and boracic acid, subsequently lixiviating the broken mass to remove free boracic acid and potassium borate. This form of the pigment is known under the name "Vert de Guignet."

The greens derived from chromium may be regarded as colours of great stability, as they do not decompose other colours, and are themselves unacted upon by sulphuretted hydrogen gas, light, or air.

Scheele's green.—This pigment I now bring before you as it has been employed in more common painting work, and being of an extremely poisonous character, I wish to show you how materials coloured with this paint may be examined for the poison. This pigment, in a state of purity, is a neutral copper arsenite, but the substance employed in the arts generally contains considerable quantities of copper oxide. The colour cannot be said to be thoroughly permanent, as it is altered by air, more especially in a moist atmosphere, and is entirely decomposed by the action of heat. This paint has been employed to a great extent in the colouring of inferior classes of wall paper, and when so employed has proved extremely deleterious to the health of persons inhabiting rooms so papered. The manner of examining this pigment for the arsenic may be carried out in the following ways. Should the pigment be obtained in the state of powder, it may be introduced into a retort such as you see arranged on the table, and treated with strong hydrochloric acid. The retort should be connected with a condenser and a quill receiver, the end of which dips under a little water. On the application of heat, the volatile arsenic chloride distills over, and is condensed in the water in the receiver. More water is then added to the condensed liquid, and sulphuretted hydrogen gas passed through it, when a precipitate of the yellow arsenic sulphide shows the presence of arsenic. This precipitate may be confirmed for arsenic by treatment with ammonium carbonate in slight excess, when it should entirely dissolve. When the green pigment has been spread on wall paper, a preferable method is, after cutting the paper in small strips, to treat it with a little caustic ammonia, when, should there be Scheele's green in the pigment, the paper will probably turn blue from the action of the ammonia on the copper. After leaving the ammonia to act for a short time, the liquid must be rendered slightly acid with hydrochloric acid, the shreds of paper filtered off, and the solution boiled with some slips of metallic copper. In the slightly acid solution a deposition of metallic arsenic takes place upon the copper, causing it to assume a steel grey colour. The slips of coated copper may now be removed from the solution, slightly rinsed with cold water, dried by gently pressing between blotting paper, and heated in a small glass tube closed at one end, when the arsenic becomes converted into arsenious acid, which condenses in small crystals on the sides of the tube. For the direct examination of a pigment such as "King's yellow," which is unacted upon by acids, the best plan is to fuse the substance with some reducing agent, such as sodium carbonate mixed with potassium cyanide or charcoal in a small tube, when the arsenic is evolved, and condenses round the upper portion of the tube as a black ring of metallic lustre. Another pigment, namely, "Schweinfurt green," also contains arsenic, and may be regarded as an "aceto-arsenite of copper," being formed by the treatment of verdigris with acetic and arsenious acids. Both these pigments are highly dangerous to health, especially when they are employed in the colouring of internal walls, as in many cases, the paint having been put on with an insufficiency of size, small particles come off, and becoming mixed with the particles of dust, are breathed by those inhabiting the rooms.

"*Verdigris*" was originally used to a considerable extent as a green pigment, but it can not be recommended, as it undergoes change

both by moisture and sulphuretted hydrogen. In certain cases also it has been found to undergo a darkening in colour, probably under the action of reducing agents. It may be regarded as a "sub-acetate of copper," but varies to some extent in its composition among the different varieties that are made. Many other greens containing copper exist, among which the most important are "Mountain green," formed from native malachite or copper carbonate; "Bremen green," or "Mineral green," which are hydrated oxides of copper; and "Brunswick green," which has for its basis copper oxychloride. Most of these pigments, if pure, are of good colour and permanent, but, in the case of Brunswick green, it is to be found frequently formed from a mixture of Prussian blue, chromate of lead, and barium sulphate, which, reacting on one another, cause the original green to assume a brownish tint.

An extremely beautiful and permanent green, which has received the name of "*Rinman's green*," or "Cobalt green," may be formed by calcining the precipitate produced by sodium carbonate in a mixture of cobalt and zinc sulphates, and consists of a mixture of the oxides of these two metals. Some recommend that the cobalt and zinc salts should be precipitated with potassium phosphate or arseniate, this giving a richer colour with more body. The arsenious acid in this case apparently undergoes volatilisation, and is not retained to any extent by the resulting pigment. Green pigments may also be obtained from the metals manganese, uranium, and titanium, but they are not of much importance.

Blue Pigments.—The blue pigments most commonly employed are derived chiefly from the compounds of iron and cobalt, with the exception of ultramarine—which contains silica and alumina in varying proportion—and one or two blues derived from copper compounds.

Ultramarine.—I bring this colour first under your notice from the great beauty and purity of its colour, and the perfect stability the pigment possesses when mixed with other paints, or in the presence of noxious gases. It consists of silica and alumina, accompanied with smaller quantities of soda and sulphuric acid. From the rarity of the mineral "lapis lazuli," which furnishes the natural ultramarine, this form of the pigment is very expensive, but the "artificial ultramarine" is manufactured in large quantities at a moderate cost, and is very good in colour and stability. The artificial variety is prepared by fusing together white clay, dried sodium carbonate, sulphur, and charcoal, which yields a mass of so-called "green ultramarine." This, however, on being washed, dried, and again roasted in thin layers with sulphur, gradually forms the blue variety. As already stated, the colour may be regarded as a permanent one, except when it comes in contact with acids, which exercise a bleaching action upon it. There are two forms of artificial ultramarine, one of which is termed "Guimet's," and the other "Gahn's."

This latter body is a compound of cobalt oxide and alumina, and does not seem to possess a definite chemical composition. By varying the proportions of cobalt, a more or less decided shade of blue may be produced; but it seems essential that the metals iron or nickel should be absent from the pigment. It mixes well with other colours without producing any deterioration, but is liable to appear of a purple shade when viewed by artificial light.

Thenard's Blue.—This is another blue containing cobalt, and somewhat similar to the pigment just described. It is formed by mixing the pink gelatinous precipitate, obtained by adding sodium phosphate to a cobalt salt, with alumina, and after drying, heating the mixture to redness in a crucible. Thenard's blue, when carefully prepared, is reported as an extremely permanent colour, withstanding the action of heat, light, noxious gases, and even acids and alkalies. Under certain circumstances this colour loses its pristine brilliancy; but this may readily be restored to it by heating the pigment with a small quantity of mercury oxide. The mercury volatilises, and the oxygen passing to the pigment, revivifies it in a very decided manner, pointing to the fact that the brilliancy of the paint probably depends on the state of oxidation of cobalt in the mixture.

Smalt.—This colour is well adapted for coarser kinds of work, but is not much used in the fine arts. It may be regarded as a double silicate of potash and cobalt, in fact, glass coloured blue by cobalt, and then crushed to a fine powder. The pigment is prepared on the large scale by roasting cobalt ore, which converts the larger portion of the metal into oxide, but still leaves a considerable quantity of arsenic and sulphur in the ore. The residue is then fused with potassium carbonate and crushed quartz, which forms the double silicate of cobalt and potassium, whilst

the other metals, such as iron, copper, and nickel, combining with the arsenic and sulphur, form a slag at the bottom of the crucible. The blue glass is poured into water so as to render it more friable by the sudden cooling. The intensity of the colour depends upon the quantity of the double silicate which the pigment contains, and the absence of iron in any quantity. It varies from a clear to a decided blue in shade. To be of good quality smalt should not be at all sandy in its nature, but should be in fine powder, holding together like flour; and when thrown into water, the deposit should exhibit the same tint all through.

Cœlin or Cerulian Blue.—This pigment is probably a compound of cobalt and oxide of tin, this body being accompanied by a certain quantity of calcium sulphate. It is a beautiful transparent blue, with a slight greenish tinge.

Prussian Blue.—Under this title may be arranged all these blue pigments which are known under the names of Antwerp, Berlin, Paris, and Turnbull's blue, and which have been considered as different compounds of iron with cyanogen, but which may often possess an identical composition. In these colours we find the iron, which is combined with the cyanogen, in two conditions, one of which is termed the ferrous (Fe″), the other the ferric (Fe‴) condition, and the colour of the body produced varies according to whether the iron salts employed are in the one or other condition. The cyanogen compound which is generally taken to form these pigments is the potassium ferrocyanide or yellow prussiate of potash; and I will now show you the difference in the body produced according to the iron salt employed. In these two jars I have solutions of ferric chloride and ferrous sulphate; now I add to both of them a solution of potassium ferrocyanide, when you see a deep blue precipitate formed in the jar containing the ferric salt, but in the jar containing the ferrous salt, a very much lighter body is obtained: the first of these bodies prepared in the proper manner constitutes the true "Prussian blue." When a solution of ferric sulphate is added to potassium ferrocyanide, a variety is obtained, which is soluble in water and which is employed to a great extent by calico printers under the name "soluble Prussian blue." This variety contains potassium as well as the iron and cyanogen, and may be represented by the chemical formula ($K_2Fe_2Fcy_2$). When, however, potassium ferrocyanide is added to ferric sulphate, the precipitate formed is insoluble in water and may be represented by the formula (Fe_4Fcy_3).

Prussian blue may also be prepared from the green vitriol or ferrous sulphate, but in this case the substance formed must be exposed for a considerable time to the air, as the precipitate at first obtained is nearly white in colour, having a different composition ($K_2Fe''Fcy$); this body, however, on exposure, becomes converted into the true Prussian blue by oxidation. I can easily show you the formation of this white variety, and its subsequent change into the blue, by shaking some iron filings with a solution of sulphurous acid, and filtering this into a solution of weak potassium ferrocyanide, when you perceive a dense white precipitate is at once formed. On pouring this, as I now do, on to a plate, you perceive that immediately it changes to a light blue, finally becoming much deeper in colour round the edge of the mass where the action of the air is more acute.

The blue pigments derived from these sources are moderately permanent, except in the presence of alkalies, which rapidly decompose them with the formation of ferric oxide. This decomposition may be seen when I treat this Prussian blue, which I have here suspended in water, with some warm caustic potash, the alkali rapidly decomposing the blue, and changing it into a brown powder. The formation of these different substances may be seen in the diagram on the wall, where the first equation represents the formation of the variety insoluble in water; the second and third the formation of the white variety from green vitriol, with its subsequent change into the insoluble blue pigment; and the fourth the formation of "soluble Prussian blue."

$$\text{I. } 2Fe_2(SO_4)_3 + 3K_4Fcy = 6K_2SO_3 + \overbrace{Fe_4Fcy_8}^{\text{Insoluble Prussian blue.}}$$

$$\text{II. } K_4Fcy + FeSO_4 = K_2SO_4 + \overbrace{K_2Fe''Fcy.}^{\text{White variety.}}$$

$$\text{III. } \overbrace{6(K_2FeFcy)}^{\text{White variety.}} + O_3 = 3K_4Fcy + Fe_2O_3 + \overbrace{Fe_4Fcy_3}^{\text{Insoluble Prussian blue.}}$$

$$\text{IV. } 2K\ Fcy + Fe\ (SO_4)\ 3 = 3K_2SO + \overbrace{K_{\overline{2}}Fe_2Fcy_2}^{\text{Soluble Prussian blue.}}$$

Little care is taken in the purification of the yellow prussiate of potash for the preparation of the common blue pigment, but it must undergo recrystallisation for the preparation of the pure variety of blue, which is sold under the name of "Antwerp blue."

Mountain blue is a basic copper carbonate, somewhat resembling the green carbonate in its constitution. It is very difficult to obtain the substance in a state of purity, and many experiments have been made to obtain, artificially, a pigment which will possess a colour resembling the natural body. The best results in this direction are probably those of Pelletier, but the artificial variety, however well prepared, does not possess the permanency which belongs to the natural variety used by the older painters, and still to be seen in a brilliant condition in some of their fresco paintings.

The qualities to be sought for in all pigments, whether taken from a natural source or artifically prepared, may briefly be stated as follows:—The substance should have great richness in the special tint required, and as great durability as possible. It should cover the surface to which it is applied with ease, and for this purpose it must possess the property of mixing thoroughly with the vehicle in which it is suspended. It is essential that the pigment should be insoluble in water, and should dry properly when spread on the canvas. Finally, care must be taken in the selection of the different colours to see that no substances are employed which will produce decomposition with other pigments. This can only be attained by the colourist paying attention to the nature of the ingredients, with due regard to their chemical constitution. The latter precaution has become all the more necessary from the introduction in later years of artificially prepared pigments, which although presenting greater variety of tints, have not that stability which characterised the more simple natural bodies employed by the older painters, and which has permitted such pigments to withstand the action of exterior agents for so long a time. Much depends also on the nature and purity of the vehicles with which the pigments are spread, and the varnishes which are used for the subsequent preservation of the pictures. I should have liked, had time permitted, to have taken into consideration some of the more important chemical points with regard to the nature of such vehicles, and their probable action on different pigments, but I find it impossible in the space at my disposal to carry out this wish.

TABLE I.

Some of the more Common Pigments, with the Chemical Substances from which they are derived.

White	Cremnitz white	White lead	$[PbCo_3. Pb(OH)_2]$.
	Chinese white	Zinc oxide	ZnO.
	Flake white	Basic nitrate of bismuth	$[Bi(NO_3)_3. 2Bi(OH)_3]$.
	Pearl white	Bismuth oxychloride	$[2(BiCl_3. Bi_2O_3). H_2O]$.
	Constant white	Barium sulphate	$BaSO_4$.
		Barium tungstate	$BaWO_4$.
	Tin white	Tin binoxide	SnO_2.
Yellow	King's yellow	Arsenic sulphide	As_2S_3.
	Cadmium yellow	Cadmium sulphide	CdS.
	Platinum yellow	Platino-chloride of potassium	$(PtCl_4. 2KCl)$.
	Turner's yellow	Lead oxychloride	$(PbCl_2. 7PbO)$.
	Mineral yellow		
	Turbith mineral	Basic mercury sulphate	$(HgSO_4. 2HgO.)$.
	Chrome yellow	Lead chromate	$PbCrO_4$.
	Zinc chrome	Zinc chromate	$ZnCrO_4$.
	Lemon yellow	Barium chromate	$BaCrO_4$.
		Strontium chromate	$SrCrO_4$.
	Naples yellow	Oxides of lead and antimony	$PbO+Sb_2O_5$.
	Yellow ochre	Ferric hydrate and clay	$[(2Fe_2O_3. 3H_2O).+Clay]$.
	Mosaic gold	Tin bisulphide	SnS_2.

Red	Red lead	Lead oxides	$[3(PbO).\ PbO_2.]$.
	Vermilion	Mercuric sulphide	HgS.
	Purple red	Basic mercury chromate	$(HgCrO_4\text{-}HgO.)$.
	Iodine scarlet	Mercuric iodide	HgI_2.
	Realgar	Arsenic sulphide	As_2S_2.
	Red ochre Colcothar	Ferric oxide	Fe_2O_3.
Green	Chrome green	Chromic oxide	Cr_2O_3.
	Cobalt or Rinmans' green	Oxides of cobalt and zinc	$(CoO+ZnO.)$.
	Mountain green	Green malachite	$[(CuCO_3.\ Cu(OH)_2]$
	Scheele's green	Copper arsenite	$CuHAsO_3$.
	Verdigris	Basic copper acetate	$[Cu(C_2H_3O_2)_2.\ CuO.6H_2O]$.
	Emerald green	Acetate and arsenite of copper	$[Cu(C_2H_3O_2)_2.\ CuHAsO_3]$.
	Terraverte	Clay coloured with iron and manganese	
Blue	Ultramarine	Silicate of aluminium, and sodium with sodium sulphide	$Na_2\ Al_2\ Si_2\ O_8\ Na_2\ S_2$.
	Mountain blue	Blue malachite	$[2\ (CuCo_3).\ \ Cu\ (OH)_2]$
	Smalt	Cobalt and potassium silicate	$CoK_2\ SiO_4$.
	Antwerp blue Insoluble Prussian blue	Ferric ferrocyanide	$Fe_4\ Fcy_3$.
	Soluble Prussian blue	Potassio ferric ferrocyanide	$K_2\ Fe_2\ Fcy_2$.
	Indigo		$2\ (C_8\ H_5\ N_5\ O_2)$.
Brown	Manganese brown	Manganese dioxide	MnO_2.
	Vandyke brown	Ferric oxide	
	Burnt sienna Burnt umber	Clays coloured with oxides of iron and manganese	
Orange	Orange chrome	Basic lead chromate	$PbCrO_4\ PbO$.
Black	Black lead Mineral black	Plumbago or graphite Impure graphite	Carbon + ash.
	Lamp black Diamond black Spanish black Ivory black Blue black	Soot from resins or tar Impure lamp black Charcoal from cork Charred bones Charcoal from vine twigs Cocoa nut and peach stones	Artificial varieties of charcoal with greater or less impurities

TABLE II.

Pigments liable to change under the influence of Sulphuretted Hydrogen, Air, and Moisture.

White ...... Cremnitz white.
Flake white.
Pearl white.

Yellow .... Turbith mineral.
Chrome yellow.
Mineral yellow.
Naples yellow.

Red .... Red lead.
Purple red.
Iodine scarlet.

Green ...... Verdigris.
Scheele's green.
Emerald green.
Mountain green.

Blue ...... Prussian blue.
Antwerp blue.

Orange .... Orange chrome.

TABLE III.

Pigments little liable to change under the influence of Sulphuretted Hydrogen, Air or Moisture.

White .... Zinc white.
Constant white.
Barium tungstate.
Tin white.

Red	Vermilion.
	Red ochre.
	Indian red.
	Madder lakes.
Yellow	Yellow ochre.
	Barium chromate.
	Zinc chromate.
	Aureolin.
	Platinum yellow.
	Raw sienna.
Green	Chrome greens.
	Cobalt greens.
Blue	Ultramarine.
	Smalt.
	Thenard's blue.
Brown	Vandyke browns.
	Raw umber.
	Burnt umber.
	Manganese brown.
	Sepia.
Black	Ivory black.
	Lamp black.
	Indian ink.
	Graphite.
Orange	Orange vermilion.
	Burnt sienna.

TABLE IV.

PIGMENTS LIABLE TO DETERIORATION WHEN IN CONTACT WITH WHITE LEAD.

Yellow...	Yellow orpiment.
	King's yellow.
	Indian yellow.
	Gamboge.
Red......	Iodine scarlet.
	Cochineal.
	Carmine.
Orange..	Golden antimony sulphide.
	Orange orpiment.
Green....	Sap green.

TABLE V.

PIGMENTS WHICH ARE LITTLE AFFECTED BY HEAT, AND MAY BE EMPLOYED WHEN THE MATERIAL HAS TO STAND THE FIRE.

White	Tin white.
	Barium white.
	Zinc white.
Red	Red ochre.
	Venetian red.
	Indian red.
Yellow	Naples yellow.
	Antimony yellow.
Green .. .	Chrome greens.
	Cobalt green.
Blue	Smalt and Royal blue.
	Ultramarine.
Orange....	Burnt sienna.
	Burnt ochre.
Brown	Burnt umber.
	Manganese brown.
Black......	Graphite.
	Mineral black.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The number of visitors to the Exhibition for the week ending Tuesday, 22nd September, was 130,822. Total since the opening, 2,897,666.

ITALIAN ALPINE CLUB.

The Italian Alpine Club, founded in 1863 at Turin, now numbers 3,717 members, who pay an annual subscription of 20 francs per annum. There are, at present, in Europe, 67 other clubs, with a total of 83,731 members.

The Italian club is subdivided into 31 sections, of which that of Turin, established in 1863, is the oldest, and has the largest number of members, viz., 506. The most recently established section is that of Campobasso, established this year, which already numbers 50 members. The section having the fewest members is that of Auronzo, with only 25. The number of members of the Milan section is 419; that of Varallo 287; and that of Florence 213. The Italian club have erected no fewer than 42 refuges in the high Alps, constructed bridges, paths, established meteorological observatories, improved mountain roads, and encouraged the small home industries amongst the Alpine populations.

The club have established at Turin, on the Monte dei Cappuccini, a hill overlooking the Po, a museum of Alpine curiosities, maps, models, and collections of minerals, dried flowers, woods, photographs, &c. The view of the Alps from the terrace of this establishment extends from Mont Argentera in the Maritime Alps, to Monte Generoso on the Lake of Como, a distance of at least 210 English miles; this panorama includes the lofty peak of Monte Viso (3,843 metres above the sea), Rocciamelone (3,537 metres), the snow-capped peaks of the Grand Paradis (4,061 metres), and at the extreme the majestic Monte Rosa (4,638 metres).

The museum contains an interesting collection of articles and tools illustrating the home industries of the inhabitants of the Italian villages of the Alps, the improvement of which the club has done much to encourage.

An international congress of the various Alpine clubs has been held this month, at Turin, in the hall of the Casignano Palace (formerly the Chamber of

Deputies), under the honorary presidency of King Humbert. An account of the congress, which was attended by delegates from most of the European Alpine clubs, is given in the newly established publication entitled *Correspondence d'Italie Anglo-Française*, published twice a week at Turin and Rome.

Correspondence.

PHILOSOPHICAL INSTRUMENTS AT THE INVENTIONS EXHIBITION.

Would you kindly allow me a little further space to reply to Mr. Tate's second letter? Had he in the first instance confined himself to the defence of his own machine, I should not have trespassed on the attention of your readers; but, in presuming to correct Professor McLeod's statement, that in my machine, certain click-springs, common to other arithmometers, had been "entirely eliminated," he wrote that I had "lately been obliged to apply springs (of a different form) to keep my number discs in their proper position." This could mean nothing else, in that connection, than that the elimination of the click-springs had proved so far a failure as to have lately "obliged" me to remedy the resulting defect by applying springs where there were no springs before.

Mr. Tate now admits that, so far from springs having been lately applied, there has only been the substitution of one form of spring for another, the previous form having been what he speaks of as "a piece of wire." It was a tempered steel wire spring.

Mr. Tate enters into an elaborate argument to prove that the springs in question have the same function as the click-springs which are absent from my machine, but upon which the correct action of his and other arithmometers depends. He founds his whole argument upon a (no doubt unintentional) misinterpretation of a sentence in my last letter. He says, "Mr. Edmondson admits that he has springs in his machine to steady the number discs when the slide is lifted." It is, perhaps, needful to explain that in all arithmometers the slide has to be lifted and moved one step or digit to the right or left in multiplication or division, and this has to be done for each digit of the multiplier or quotient. It is this lifting to which Mr. Tate alludes, and he is correct in saying that it is a "constant and necessary" part of almost every operation with the machine. If, therefore, it were true that I had made the admission he attributes to me, his point would be, in part, proved. But I have not admitted it, and it is not the fact. I am prepared to strip all the springs in question from any one of my machines, and still to guarantee its correct action and the steadiness of the discs during the lifting and stepping of the slide. I have often worked my machines experimentally *without the springs*, and have found them to work and "step" as correctly without as with them. This, indeed, was one of the desiderata aimed at, and successfully attained, in the construction of the instrument. When Mr. Tate knows my machine better, he will perhaps discover (what he evidently does not at present perceive) the simple and all-sufficient reason why my discs have no tendency to go wrong when the slide is lifted and stepped, as they would be liable to do in all other arithmometers if left without springs.

What then is the use of the springs in the circular machine? It is their duty to steady the discs, not while the machine is working, but when the circle (or slide) is "lifted out of the machine," as stated in my last letter, in a sentence which Mr. Tate has so remarkably misinterpreted. For the purpose of showing, cleaning, or oiling the internal mechanism, the slide is "lifted out," or entirely separated from the body of the instrument. Then, and then only, the discs are liable to become displaced. But such displacement is only of consequence in so far as it interferes with the circle's going properly down into its seat when replaced in the instrument. It does not affect the reckoning, but it takes time to readjust. To save this loss of time is the simple and inconspicuous duty of the springs in question. Mr. Tate might almost as well say that the hairspring and the mainspring of a watch have identical functions, as compare the constant and destructive duty of the click-springs which I have eliminated, with that of the quiescent and practically indestructible springs which I have added for a different purpose.

JOSEPH EDMONDSON.

Halifax, 21st September, 1885.

General Notes.

KING'S COLLEGE, LONDON.—In connection with the evening class department, a class of Metallurgy commences October 5th, under the direction of Professor A. K. Huntington. A course of lectures on "The Properties of Metals and Alloys, and their uses in the Arts," will be given on Monday evenings, from eight to nine, and will include the study of various metals in common use. Especial attention will be devoted to the metallurgical requirements for the Examinations of the City and Guilds of London Institute in metal plate work, plumbing, and iron and steel. A course of lectures will also be given by W. G. McMillan on "Fuel," on Monday evenings, from seven to eight, and will include the subjects required for the City and Guilds Institute examination in fuel. A class of practical metallurgy will be held on Fridays, from seven to nine p.m., in the metallurgical laboratories, to enable students to become practically acquainted with the properties of metals, and the general methods of assaying and mechanical testing, &c.; and also, if they desire it, students may prepare for the examination of the Science and Art Department in practical metallurgy.

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FRIDAY, OCTOBER 2, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

OWEN JONES PRIZES FOR DESIGNS FOR FURNITURE.

The Council are trustees of the sum of £400, presented to them by the Owen Jones Memorial Committee, the balance of the subscriptions to that fund, upon trust to expend the interest thereof in prizes to "Students of the Schools of Art, who in annual competition produce the best designs for household furniture, carpets, wall-papers, and hangings, damasks, chintzes, &c., regulated by the principles laid down by Owen Jones;" the prizes to "consist of a bound copy of Owen Jones's 'Principles of Design,' a Bronze Medal, and such sums of money as the fund admits of."

The prizes will be awarded on the results of the Annual Competition of the Science and Art Department. Competing designs must be marked "In competition for the Owen Jones Prizes."

No candidate who has gained one of the above prizes can again take part in this competition.

The next award will be made in 1886, when six prizes are offered for competition, each prize to consist of a bound copy of Owen Jones' "Principles of Design," and the Society's Bronze Medal.

Proceedings of the Society.

CANTOR LECTURES.

DISTRIBUTION OF ELECTRICITY.

By Prof. George Forbes.

Lecture I.—Delivered February 2nd, 1885.

Introductory.

When asked to give a course of lectures on the distribution of electricity, I was very pleased to accept the task, because I felt that such a work was much needed. Numbers of engineers have worked out very fully numerous problems in electrical distribution for their own wants, but no classification of systems has been attempted, and no work has been published to assist the engineer in drawing out specifications and selecting between systems.

I also felt that a principal reason why public electric lighting had made so small progress was the difficulty of planning a system of distribution, and the probability that an expensive system proposed to-day would be superseded by a more economical system next year.

The low pressure system called multiple arc distribution is enormously expensive, and necessitates the engine-house being in the centre of the populous district lighted, and this is seldom feasible. A high pressure system gets over this difficulty, but we can hardly say that any such system has yet been brought to practical perfection. This is what is wanted for large central station lighting, although much can be done even on the expensive low pressure plan.

At first I proposed to make these lectures extremely popular. But as I progressed, I found that I should sacrifice too much by avoiding technicalities, and I felt that the time I have spent on their preparation would have better fruit if I addressed myself more directly to brother engineers, but still in language clear enough to be understood by a non-technical audience.

I shall use the Parliamentary term "pressure" in these lectures, signifying difference of electric potential between the two conductors. Those who have had most to do with large practical installations know best what serious items are the cost of conductors and the purchase of a site. The latter would

be enormously diminished if the works could be at a distance. It is my duty in these lectures to see how far in each system of distribution the cost of conductors can be diminished; and wherever economy clashes with other facts, and introduces new engineering difficulties, it will be my duty to show how these engineering difficulties may be removed.

One thing I must insist upon. If the economical considerations lead us to a large conductor, we must recommend that large conductor. No financial questions of a difficulty in raising the money may be allowed to influence the engineer in recommending a smaller conductor than his calculations have proved to be the most economical in the end.

You all know the different systems which have been proposed for lighting. You know how arc lights have been distributed in series, and how incandescent lamps have been put on multiple arc in large stations. More especially you are acquainted with what has been done in America in this matter. In some cases only has a special system been thoroughly worked out; and in very few cases, I fancy, have different systems been relatively compared and pursued so as to bring out the most economical conditions possible.

Besides these different systems I have spoken of—the series and multiple arc systems—you are aware that the latter, the multiple arc, is divided into a number of different modes of distribution. You have all heard people talking about the network system, the system with three mains, and also of lines-of-centres distribution. These are different modes of multiple arc system. And so also we have another one, which is called the multiple series system, which has been used to a certain extent, and very successfully used, but which has very radical defects in it which have prevented its general adoption; at the same time, many distinguished engineers believe that, in the future, there may be a possibility of making this system efficacious, and of removing the defects which are in the way. The objection to the ordinary multiple system, where all the lamps are connected to two massive mains, or to a number of wires which are so connected together as to make two massive mains, is the enormous cost of the conductors.

Besides the difficulty that the Electric Lighting Act is unworkable, as every unprejudiced person must admit that it is, there is no doubt another fact which has largely hindered electric lighting, and that is the enormous cost of the mains. And not only that, but the multiple arc system introduces another serious expense. It becomes essential with such large mains to have our central station and our engines in the centre of the district which is being supplied. Now, in a thickly populated neighbourhood, such as it would be economical to light on the multiple arc system, it is very difficult to get a site for your engine and dynamos, and this has been acknowledged by those who have tried to undertake the system in London to be one of the most serious objections to the multiple arc system. Thus at every point we see that it is of the utmost importance that engineers should devote their attention to economy in the construction of their mains, to enable us to have a good supply after the most economical system of mains which is possible, whether that system be multiple arc or multiple series, or any other of the modifications which have been proposed. It is at present the earnest hope of thousands and thousands of the inhabitants of our great towns that they may have electricity supplied to their houses from central stations, just as gas is at the present time. They have been prevented hitherto from obtaining such a supply, partly by the cost of production and supply, and partly by the jealousies of municipal authorities acting through Parliament, and who have undertaken gas speculations. The public who want the electric supply will not endure this much longer, and it becomes a matter of importance for electricians to see how far they are able to reduce the cost of production and supply.

Production.

The question of production is one which has been very fully discussed. The dynamo machine affords the most economical means of production, and will probably continue to do so. If ever it be superseded, it can only be by a step in our knowledge entitled to the name of a great scientific discovery. Such discoveries do not come at our bidding. They are evolved in the laboratory of the patient scientific inquirer, and seldom in the workshop of the speculative inventor. In selecting our dynamo, cost of manufacture and maintenance, and cost of production of electrical energy, are the chief items to be considered. For a central station with 10,000 lamps, we want to have about 1,000 electrical horse-power in the circuit. We may use high-tension machines in parallel, or low-tension machines in series, until we get in the external circuit 7,500 ampères and 100 volts (if such be the class of

lamp we are using), or we may use a single machine to produce the same effect. It is better to use a large number of machines, so that they may be each removable and able to be replaced by another when repairs are necessary. But it is a matter of indifference what class of machine we employ (high-tension in parallel, or low-tension in series), except so far as cost is concerned. We have simply to choose the machine which gives the greatest output of energy in the circuit at the least expense.

I have drawn attention to this because it is important, and because few people have thought of combining low tension machines in series. And I have confidence that the simplicity of construction of these machines, their cheapness and economy of maintenance, and their infinitesimal internal resistance, will lead them to be generally adopted.

The question of primary batteries must be laid on one side as being quite too costly. If a battery were made practical in which coke or charcoal should be consumed instead of zinc, we might discuss the matter. In 1880, I made a number of partially successful experiments in this line, but with no very definite result. If, on the other hand, the residual products of a battery were valuable, and there was unlimited demand for them, some progress might be made. As yet we have no reason for hope in this direction. Secondary batteries being dependent entirely upon the dynamo, are connected with the supply rather than with the production of the current.

There are other systems, such as that which utilises alternate currents combined with the induced current distributors on the plan perfected by Messrs. Gaulard and Gibbs. This also is rather a question of supply and distribution, and will be left to a later stage for discussion.

Leaving now the question of the production of electricity on one side, the next point to be considered is its distribution and supply. But before attacking this problem directly, I should like to make a comparison of it with the similar problem with respect to gas.

Comparison with Gas Distribution.

The production of gas is a somewhat extensive laboratory experiment enlarged to a commercial scale. The distillation of coal, and the subsequent treatment of the gas by condensers, scrubbers, and lime purifiers, previous to its admission through the regulator and station meter to the gas holder, is really a complicated process compared with the production of electricity. In its distribution through mains to the houses of individuals, the problem is very similar to the problem for electricity. A certain pressure is given to the gas at the central station. With this pressure it must be forced through the mains, and must be delivered to the gas-jets of consumers at a definite pressure. The pressure must not vary seriously with the number of jets in use, nor with the position of a house in the district. There must be no leakage in the pipes, or as little as possible. In all these points electricity has its analogue. Moreover, a difference of pressure will establish itself if the flow of gas and the resistance of the pipes to this flow are large; and the larger the pipes the less is this resistance. Hitherto, the analogies are very striking. There are, however, two points of difference. First, in gas-distribution the resistance to the flow of gas is not proportional inversely to the area of the pipe, so that while with electricity the resistance of 100 parallel wires is the same as that of one wire 100 times the section, this is not the case with gas, where the hundred pipes have much more resistance than the simple pipe of 100-fold section. Secondly, the cost of gas mains is not proportional to their sectional area, and still less is it proportional to the current of gas it has to carry. With electricity, on the one hand, the cost of mains always increases at least in proportion to the current. The consequence of these facts is, that the cost of mains is an incomparably more important matter in the case of electricity than in that of gas. This is what renders the distribution of electricity so important and worthy of study by the electrician. Upon the arrangements made under this head depends very largely the question whether or not electricity is as cheap a means of lighting as gas.

While comparing gas and electricity, it is surprising to see how great difficulty has been met in introducing the latter. When gas was introduced, the public had no experience of, nor occasion for confidence in, a general supply, and the laying of pipes was a leap in the dark. There was no knowledge of the size of pipes required, there was little means of even guessing at the probable consumption. At the present time a public supply of light is well understood and appreciated, and we know well what currents our wires will carry. Moreover, from the known gas consumption, we can form a more accurate estimate of the probable demand for electricity.

Then, at the same time when gas was introduced, the burners were infamous (merely a hole in the top of a closed tube), and the flame was smoky and sulphurous, consumed the oxygen, poisoned the air, and blackened surrounding objects, while its smell was odious and unwholesome. It was not known how to prevent leaks, and leaks meant explosions. The inexperience of the public was certain to leave cocks turned on—hence explosions again, and deaths from suffocation by gas. Gas gave a naked flame which is a constant source of danger, while to-day the incandescent light cannot set light to anything. Yet, in spite of all these advantages, the difficulty of introducing electricity has been far greater than was that of introducing gas. The electric light must contend against a monopoly. Gas had a fair and open field. Our Legislature has favoured the monopolists; the legislators for gas encouraged its development. Gas met with financial speculators just as electricity has done. The monopolists who have sprung into existence are the one deterrent cause.

Distribution of Electricity.

Passing now to the subject of these lectures, it will be well if we give a general survey to day of the various points with which we have to deal, and of the different plans of distribution, which must afterwards be considered in detail.

The first thing to be noticed is that, in order to give electricity a fair chance in competing with, or supplementing, the gas supply, the cost of one of its most expensive parts, *i. e.*, the conducting mains, must be reduced as low as possible. Various schemes have been proposed with one advantage or another. Some systems have been devised whose speciality is that they do not allow the potential to vary much. Other systems have specially in view the avoidance of total darkness if an accident should occur at any point. At present it is essential that these considerations should be second to economy. Let us first get the most economical system, and all things else shall be added hereafter. Now, in attempting to reduce the size of our conductors, we meet with three difficulties:— 1. With small conductors, energy is wasted in heating them, and this may become very considerable. Thus, while capital outlay on copper is saved by small conductors, the annual consumption of coal is increased, and large engines and dynamos are required. 2. With large currents this heat may be sufficient to injure the insulation. It also increases the resistance of the conductors; and if the conductors be underground, the heat may become unpleasant to foot-passengers. Clearly, the conductors must be large enough to prevent such troubles. 3. There is a loss of potential in the mains, which is greater where these are smaller. This loss is also greater in proportion to the number of lamps fed by the main. The fall of potential with one lamp might be one-tenth of a volt, and with 100 lamps it would be ten volts. So large a variation under varying conditions of consumption cannot be permitted, and the conductors must be large enough to prevent any such variations.

I propose now to say a few words on each of these heads, in order to prepare the way for criticising different systems of conducting mains.

Now, let us first look at the problem with a few figures before us, to see on what scale we are dealing. Suppose that we are using a conductor of a square inch section to carry 1,000 ampères. The resistance of 100 yards of that conductor of pure copper would be 0·0024 of an ohm. Now, the energy which is used up is given you by the calculation C^2R divided by 746. That is equal to 3·2 horse-power used up in every 100 yards of our conductor for every 1,000 ampères. Now what is the cost of this electrical horse-power per annum? It is usually considered safe to say a horse-power costs £10 per annum, but, owing to the period in which electricity would be used, this is not a safe figure. Let me begin by considering £20 as the cost of horse-power. £64 is the cost of the total horse-power. We have wasted in four years in every hundred yards £256; in twenty years £1,280 is wasted in that conductor. Now, if I double the size of my conductor, I have the quantity of power wasting reduced to £640. The question comes to me, would it cost more than £640 of capital to lay down an extra hundred yards of a similar section? No, it would not; and, therefore, it is economical to double my conductor. And so we go, step by step, until we find that the gain is just equal to the extra expenditure of capital in the laying down of conductors, and then we have arrived at a satisfactory arrangement. You will easily see if you work this out. Now this is an important point, in fact one of primary importance. It was first approached by Sir William Thomson in an address to the British Association, in 1881, in which he read a paper on "The

Economy of Metal Conductors of Electricity," and, in that most interesting paper, he arrived at the conclusion that the interest spent upon the capital of the conductors should be equal to the value of the energy which is wasted annually in these conductors.

The first question which becomes a trouble is, what are we to consider the cost of electrical horse-power? There are two ways of looking at this problem, and we will just glance at them independently. First, let us take the case of an installation which has been carefully estimated for; and let us see there, after the whole of the buildings, distributing and supply plant, and everything has been laid down, what is the cost of each horse-power of electricity, if you like to call it so. To give you a perfectly unbiased example, I have taken the figures, kindly furnished me by Mr. Crompton, of a large installation for which he carefully prepared estimates. I find, on looking into this, that in this case the cost of electrical horse-power—of course depending on the number of hours used during the year—if it was for 1,000 hours, the cost of horse-power came to about 5d.; for 2,000 hours in the year, 3·5d.; and for 3,000 hours only 3d.; and that means for the year in these three cases, it would be 5,000 pence, 7,000 pence, and 9,000 pence. Now, the next question that comes before us is, what is the number of hours we are supposed to use our electricity? There is very little doubt that about 1,000 hours is probably a fair average consumption for people in a town; but I think it very likely that, at any rate in the first installation set up, a certain selection will be possible, which will raise the average a little higher. For my own purposes at present, I am going to assume 1,500 hours; if you prefer another value, you can work it out yourselves to suit it. That will be the average cost of those two, which comes almost exactly to £25 a year. Now, if you work out the cost of the energy wasted in a 1,000 yards conductor, you will find, I think, that the following figures are energy wasted in the conductor for $3\frac{1}{2}$ in., 4 in., $4\frac{1}{2}$ in., 5 in., $5\frac{1}{2}$ in., 6 in., and $6\frac{1}{2}$ in.; the amount is £22·8, £20, £17·8, £16, £14·5, £13·2, and £12. Therefore, the gain in passing from any one to the next is 2·8, 2·2, 1·8, 1·5, 1·3, and 1·2. These are the gains which there are in increasing the size of the conductor.

Up to this point it is all plain sailing, a matter of plain calculation. The next thing is, What is the interest on the capital which is expended? This, of course, depends on the way in which the mains are laid, and different people have different ideas about how they should be laid. Many people lay mains at present with stranded cables. For my own part, I cannot see what is the object of doing this; it is the most expensive form in which you can produce your copper, and really nothing is to be gained. It seems to me simply to arise from the fact that cables we used previously were submarine cables, and certainly they are of great advantage there; but why they should be used on land, where there is no strain, I see no earthly reason. Others think they should be laid in massive bars of semicircular shape, covered with bituminous compound: others, in flat sheets laid in troughs. At any rate, every person differs from every other, and consequently every person must have a different value for his cost of copper. But I have taken it as an example, simply, and you need not take the value I use. Take the £100 a ton as the cost of adding an additional amount of copper to our mains, after the troughs and so on have been laid. In that case the interest upon it depends upon the percentage which we allow. Now, what are we to allow? Ought it to be 5, $7\frac{1}{2}$, or 10? That, again, is a question for the engineer to determine for himself. But allow me to point this out, that when we are increasing the size of our mains, really we ought to be diminishing the percentage allowed for maintenance. The wear and tear is less, heating is less, the danger to insulation is less; everything leads us to believe there is a less cost of maintenance with a large conductor than with a small one. This is a very important point. Each one must judge for himself whether to take 5, $7\frac{1}{2}$, or 10 per cent. He will find with 5 per cent. the annual cost is 1·27, at $7\frac{1}{2}$ per cent. 1·91, at 10 per cent. 2·55; so that what we have to do is to find that size of conductor which should equal the interest which we happen to consider the right interest. Supposing 5 per cent., then we have 1·27 settled, which gives 6 inches; $7\frac{1}{2}$ per cent., 1·81, about 4 or $4\frac{1}{2}$ inches; and 10 per cent., 2·55; between 3·5 and 4 inches for a thousand ampères. I have gone through this example carefully just to give you a clear conception of the way in which the problem is to be worked out, but I think you may very safely say that the consumption I have taken is too large. It is perfectly true that this estimate to which I have alluded includes the cost of buildings, dynamos, boilers, and other machinery, the

mains, and also the annual cost of coals at 18s. per ton. Well, all these points do come in, therefore it is a question for each one to consider for himself how far these things are to be divided in this way. It may be said by some, however, that it is desirable only to look upon our plant as being fixed, and supposing we want to carry extra current on the same size of conductor, would it be wise to do so or not?

We may ask, "With a working station, what would be the extra cost for energy wasted if we increased the current for the same section of wires?" The answer might be given that everything is in place and paid for, except an extra engine and dynamo, and the cost of coal, oil, waste, and petty stores for the extra energy. The cost of a mechanical horse-power so reckoned is, say, 0·75d. per hour with coal at 21s. the ton, say 1·00d. for an electrical horse-power per hour, including loss of transformation, besides the cost of the dynamo, *i.e.*, 1500d., or £6·250 per horse-power per annum of 1,500 hours. The cost of dynamos is £20 per 1,000 watts of maximum output, or £7 18s. per horse-power, which, at 15 per cent., is £1 2s. 6d. per annum. Thus the whole annual charge per horse-power, in this way of looking at it, is:—

Power	£6·250
Dynamo	1·125
Total charge	7·375

Now, we have seen above that when a conductor of one square inch section carries a current of 1,000 ampères, the loss of energy per 100 yards is 3·2 electrical horse-power, which is £23·599 per annum. Our Table now becomes the following:—

Section in sq. in.	Cost of waste energy.	Gain for 1-10 inch increase.	Extra cost of mains at 5 per cent.
	£	£	£
2·50	9·440		
		0·863	0·635
2.75	8·577		
		0·711	0·635
3·00	7·866		
		0·605	0·635
3·25	7·261		
		0·518	0·635
3·50	6·743		

It is not fair to allow more than 5 per cent. on the extra copper, as there is no extra attention required, in fact probably less attention, owing to the smaller development of heat. This gives the maximum economy at 3 to 3·25 inches the 1,000 ampères. Where the cost of an electrical horse-power is 0·8d. in place of a penny (exclusive of interest and depreciation in the dynamo) the economical size comes out 2·5 square inches to the 1,000 ampères.

I have now gone very fully into the question of the most economical size of conductors. But it is one of prime importance in the whole of our problem; and in conclusion, I will furnish you with a Table which I find to be of great use.

The engineer can choose his facts for himself absolutely, can choose what he considers to be the right value of the electrical horse-power every year for the number of hours he proposes to run. He can also choose the cost of copper which he thinks it will suit him to lay. Having done that, he proceeds in this manner: I will take as an example copper costing £100 a ton; take $7\frac{1}{2}$ as the rate of interest; I look along the column of Table II*b*. (p. 1035) until I find £100, look down until I come to $7\frac{1}{2}$, and find the figure ·316. I then look to the top of the Table II*a*. (p. 1035), and I have £8 a year, say, for my electrical horse-power. I look along the column of £8 a year until I find the figure nearest to ·386, and I find that it comes to a place beneath the number 2·7; in that case 2·7 would be the square inches which are required for the main on those conditions imposed by the engineer himself. I have given another Table (p. 1034) for continual reference, showing the resistance of 100 yards and various other facts, also the current which will heat the wire.

Before leaving the subject of the cost, allow me once more to impress upon you that I consider this matter of primary importance, and no consideration must ever lead the engineer to deviate from the strict rules which regulate the cost. It may be in some special cases not always practicable to regulate our wires to carry the current exactly at this rate. It may be because it is easy to get a stock of conductors at slightly different size, or it may be inconvenient to be always varying the estimate in the size. But these principles must be gone into for every part of the scheme, and in our practical application we must stick as closely to our results arrived at there as we possibly can. It is no use for the engineer to say that financial people will not bring forward the money for these costly mains. The engineer, in my way of looking at it, has no right to look at what the financiers want to do. He must tell them honestly what is the most economical thing to do. If the financier wants to lay out capital in a particular direction,

knowing that he will be causing a waste of energy, the engineer ought to have nothing to do with such matters. He ought honestly to give the value of the current which is most economical.

I have dealt now fully enough with the first cause that prevents us from diminishing the thickness of our conductors. The second cause why we should not reduce too much, is the heating of the conductors. There are, in this, three injurious facts; in the first place, it spoils the insulation; the insulating power of the material diminishes by being heated, and the material itself becomes injured; moreover, when it is hot, it usually becomes soft, and the conductors can sink into it, and thus become decentralised. And in the second place, the conductors themselves are injured, because their resistance is increased by the increase of temperature, and these increases of temperature, mark you, are very considerable. And in the third place, the increase of temperature may be very serious, and may actually be objectionable along the streets. I have here a small piece of cable which shows the decentralising action of bituminous compound. This has been lying for six or eight months in a cool part of a cool room, always lying in the same position. I believe when I got it it was perfect, but in a cool place it gradually sunk, and now it is very decidedly out of centre. An old experiment which I used to show when I held my chair at Glasgow, illustrates the viscosity of objects. It was first suggested to me, and I first saw it done, by Sir William Thomson in his laboratory. A block of hard brittle pitch—or shoe-makers' wax would serve the same purpose—is set with a bullet on the top and corks underneath; in six months the bullet will have sunk into the pitch, and the corks will have risen several inches up through it. This simply shows you how such bituminous compounds must be carefully watched, and how very objectionable is any viscous material in the way of decentralising the conductor.

Now, as to the question of heating conductors, I will not take up much of your time this evening, because I have already, in a paper which I read at the Society of Telegraph Engineers last year, gone into the question very fully. It used to be supposed by some that if the currents in different wires were proportional to the section of the wire, the heating would be the same in all. This is not so, and when we look into the matter we could not expect it to be so. Heat is generated in a wire at a steady rate, and, if the temperature of the wire has reached a stationary condition, the same quanity of heat is carried off from the surface of the wire.

I showed by experiment, in 1882*, that to give the same heating in different wires (when these wires are small) the diameters of the wires should be nearly proportioned to the currents they have to carry.

I will show you by a simple experiment that if the currents should be proportional to the section, the thicker wire would get hottest. Here I have two wires of the same length; one is ten times the thickness of the other. I unite their ends in parallel and send a current through. The current splits up into two parts proportioned to the section of the wires. Both wires get hot, but the thick one hottest, as you see by its white incandescence, whilst the other is not luminous.

I only draw your attention to the question now, because there is an important point which, I am glad to say, needs correction. A discovery has been made of an error near the end of the paper which might be misleading, and which probably has misled some. I will give you a corrected edition of it.

Here is the Table to which I have referred. It gives you underground conductors. I have recommended sheets of copper for underground conductors, because the temperature is far less raised when you have a thin conductor.

Width in inches, of copper conductor, 1 cmr. thick.	Cross-section in square inches.	Current to raise surface temperature 10° C.
		ampères.
3·2	0·25	250
12·7	0·98	1,000
38·1	2·95	3,000
63·5	4·92	5,000
127·0	9·84	10,000
889·1	68·88	70,000

This is a most important point. We have absolute control over the temperature; by widening out our sheet we have diminished temperature, and can make the heat of conductors subservient to economy.

It is not essential that copper sheet should be used. The same mass of copper put into rods, or wires side by side, would produce the same effect if the average thickness of copper con-

* British Association Report.

tinues to be one centimetre, and these rods might be insulated in any way, or put in pipes. The depth at which these are laid does not affect the heat of the surface of the pavement so long as the depth does not exceed two feet, but the temperature of the conductor itself is greater at the greater depth.

It is satisfactory to find that the considerations of heating the insulation and heating the surface of the pavement, lead to the same result

TABLE I.

B.W.G.	Diameter in Inches.	Section in square inches.	lbs. Copper per 100 yards.	Resistance per 100 yards at 15·5° C., or 60° Fah.		Wire heated to 9° above temperature of air.		Wire heated to 25° above temperature of air.		Diameter in Inches.	B.W.G.
				B. A. Units.	Legal Ohms.	Current.	Loss in Volts.	Current.	Loss in Volts.		
							per 100 yds.		per 100 yds.		
	2·26	4·0	4608·	·000634	·000627	1514·	·998	2490·	1·730	2·26	
	2·11	3·5	4032·	·000724	·000716	1384·	1·042	2246·	1·783	2·11	
	1·95	3·0	3456·	·000845	·000835	1228·	1·079	1995·	1·847	1·95	
	1·78	2·5	2880·	·00101	·000999	1072·	1·125	1739·	1·931	1·78	
	1·60	2·0	2304·	·00127	·00126	913·	1·205	1482·	2·059	1·60	
	1·38	1·5	1728·	·00163	·00161	732·	1·288	1188·	2·187	1·38	
	1·13	1·0000	1152·	·00253	·00250	542·1	1·426	880·0	2·446	1·13	
	1·00	·7854	904·78	·00326	·00324	451·5	1·513	732·7	2·586	1·0	
	·75	·44178	508·93	·00584	·00578	293·0	1·746	475·5	2·991	·75	
	·707	·39250	452·16	·00653	·00651	268·0	1·800	435·2	3·081	·707	
	·500	·19635	226·18	·01307	·01292	159·4	2·139	258·6	3·659	·500	
0000	·454	·1618	186·39	·01567	·01550	138·1	2·248	224·1	3·854	·454	0000
000	·425	·1419	163·47	·01786	·01766	125·1	2·323	203·0	3·977	·425	000
00	·380	·1134	130·64	·02236	·02211	105·7	2·456	171·4	4·201	·380	00
	·354	·09842	113·37	·02605	·02576	95·1	2·546	154·3	4·357	·354	
0	·340	·09079	104·60	·02824	·02793	89·4	2·594	145·1	4·442	·340	0
1	·300	·07068	81·42	·03637	·03597	74·0	2·755	120·1	4·722	·300	1
2	·284	·06334	73·00	·04048	·04003	68·63	2·850	111·4	4·880	·284	2
3	·259	·05268	68·68	·04867	·04823	59·60	2·981	96·7	5·102	·259	3
4	·238	·04448	51·61	·05764	·05700	52·37	3·102	85·0	5·315	·238	4
5	·220	·03801	43·78	·06740	·06665	46·5	3·213	75·5	5·521	·220	5
6	·203	·03236	37·27	·07937	·07849	41·27	3·360	66·97	5·762	·203	6
7	·180	·02544	29·3	·1006	·08943	34·31	3·553	55·69	6·084	·180	7
8	·165	·02138	24·62	·1199	·11857	30·25	3·728	49·09	6·384	·165	8
9	·148	·01720	19·81	·1492	·14643	25·28	3·878	41·03	6·630	·148	9
10	·134	·014102	16·25	·1812	·17919	22·12	4·133	35·90	7·075	·134	10
11	·120	·011309	13·00	·2267	·22418	18·74	4·366	30·41	7·473	·120	11
12	·109	·009331	10·74	·2748	·27175	16·25	4·589	26·38	7·857	·109	12
13	·095	·007088	8·16	·3617	·35769	13·09	4·866	21·25	8·332	·095	13
14	·083	·005410	6·23	·4739	·47064	10·84	5·280	17·58	9·031	·083	14
15	·072	·004071	4·68	·6298	·62281	8·723	5·646	14·14	9·652	·072	15
16	·065	·003318	3·82	·7727	·76412	7·481	5·931	12·14	10·169	·065	16
17	·058	·002642	3·04	·9711	·96032	6·371	6·354	10·24	10·771	·058	17
18	·049	·001885	2·07	1·3598	1·3447	4·876	6·813	7·95	11·691	·049	18
19	·042	·0013854	1·60	1·8502	1·8297	3·883	7·385	6·31	12·658	·042	19
20	·035	·0009621	1·108	2·6650	2·6354	2·953	8·087	4·80	13·866	·035	20

Legal volts. 96 per cent. conductivity copper. Heating of bare copper wire, emissivity = ·00025 C.G.S. units.

TABLE IIa.

Section per Thousand Amperes in Inches.

Annual Cost of Electrical Horse-power. £	1	1·1	1·2	1·3	1·4	1·5	1·6	1·7	1·8	1·9	2	2·1	2·2	2·3	2·4	2·5
5	1·628	1·356	1·147	·980	·857	·746	·658	·585	·523	·471	·426	·386	·355	·324	·298	·276
6	1·954	1·627	1·377	1·176	1·028	·895	·790	·702	·628	·565	·511	·463	·426	·389	·358	·331
7	2·279	1·898	1·606	1·372	1·199	1·044	·921	·819	·733	·660	·596	·540	·498	·454	·417	·386
8	2·605	2·169	1·836	1·568	1·370	1·194	1·053	·936	·838	·754	·682	·618	·569	·518	·477	·442
9	2·930	2·441	2·065	1·764	1·542	1·343	1·185	1·053	·942	·848	·767	·695	·640	·583	·536	·497
10	3·256	2·712	2·295	1·960	1·713	1·492	1·316	1·170	1·047	·942	·852	·772	·711	·648	·596	·552
11		2·983	2·524	2·156	1·885	1·641	1·448	1·287	1·152	1·037	·937	·849	·782	·712	·656	·607
12			2·754	2·352	2·056	1·790	1·580	1·404	1·256	1·131	1·022	·926	·853	·778	·715	·602
13				2·548	2·227	1·940	1·711	1·521	1·361	1·225	1·108	1·004	·924	·842	·775	·718
14					2·398	2·089	1·843	1·638	1·466	1·319	1·193	1·081	·995	·907	·834	·773
15						2·238	1·975	1·755	1·570	1·414	1·278	1·158	1·066	·972	·894	·828
16							2·106	1·872	1·675	1·508	1·363	1·235	1·137	1·037	·954	·883
17								1·990	1·780	1·602	1·448	1·312	1·208	1·102	1·013	·938
18									1·884	1·696	1·534	1·390	1·279	1·166	1·073	·994
19										1·790	1·619	1·467	1·351	1·231	1·132	1·049
20											1·704	1·544	1·413	1·296	1·192	1·104

£	2·6	2·7	2·8	2·9	3·0	3·1	3·2	3·3	3·4	3·5	3·6	3·7	3·8	3·9	4	4·5	5·0	5·5	6·0	£
5	·255	·237	·221	·206	·192	·180	·170	·160	·150											5
6	·305	·284	·265	·247	·230	·216	·203	·192	·180	·170										6
7	·356	·331	·309	·288	·269	·252	·237	·224	·210	·199	·188									7
8	·407	·378	·353	·329	·307	·288	·271	·256	·240	·227	·215	·203								8
9	·458	·426	·397	·370	·346	·324	·305	·288	·270	·256	·242	·229	·217							9
10	·509	·473	·441	·411	·384	·360	·339	·320	·300	·284	·269	·254	·241	229						10
11	560	·520	·485	·452	·422	·396	·373	·352	·330	·312	·296	·279	·265	·252	·240					11
12	·611	·568	·529	·493	·461	·432	·407	·384	·360	·341	·323	·305	·289	·275	·262	·206				12
13	·662	·615	·573	·534	·499	·468	·440	·416	·390	·369	·350	·330	·313	·298	·283	·224	·181			13
14	·713	·662	·617	·575	·538	·504	·475	·448	·420	·398	·379	·356	·337	·321	·305	·241	·195	·162		14
15	·764	·710	·662	·617	·576	·540	·509	·480	·450	·426	·404	·381	·362	·344	·327	·258	·209	·174	·147	15
16	·814	·757	·706	·658	·614	·576	·542	·512	·480	·454	·430	·406	·386	·366	·349	·275	·223	·186	·156	16
17	·865	·804	·750	·699	·653	·612	·576	·544	·510	·483	·457	·432	·410	·389	·371	·292	·237	·199	·166	17
18	·916	·851	·791	·740	·691	·648	·610	·576	·540	·511	·484	·457	·434	·412	·392	·310	·251	·209	·176	18
19	·967	·899	·838	·781	·730	·684	·644	·608	·570	·540	·511	·483	·458	·435	·414	·327	·265	·220	·186	19
20	1·018	·946	·882	·822	·768	·720	·678	·640	·600	·568	·538	·508	·482	·458	·436	·344	·279	·232	·196	20

TABLE IIb.

Cost of Laying one additional Ton of Copper.

Per-centage allowed for interest and depreciation per annum.	£60	£65	£70	£75	£80	£85	£90	£95	£100	£110	£120	£130	£140	£150	£200	£250	£300	£350	£400	£450	£500	Per-centage allowed for interest and depreciation per annum.
5	·154	·167	·180	·193	·206	·219	·231	·244	·257	·283	·309	·334	·360	·385	·514	·643	·772	·900	1·029	1·157	1·286	5
7½	·231	·251	·270	·289	·309	·328	·347	·366	·386	·424	·463	·501	·540	·579	·771	·964	1·157	1·350	1·543	1·736	1·929	7½
10	·308	·334	·360	·386	·411	·437	·462	·488	·514	·565	·617	·668	·720	·770	1·029	1·286	1·543	1·800	2·057	2·315	2·571	10
12½	·385	·418	·450	·482	·515	·546	·578	·610	·643	·707	·772	·835	·900	·964	1·285	1·607	1·929	2·250	2·572	2·893	3·205	12½
15	·463	·501	·540	·578	·617	·656	·694	·733	·771	·849	·926	1·003	1·080	1·155	1·543	1·928	2·314	2·700	3·086	3·471	3·857	15
20	·616	·668	·720	·771	·824	·875	·925	·976	1·029	1·131	1·235	1·336	1·440	1·540	2·056	2·571	3·089	3·600	4·115	4·629	5·144	20
25	·771	·835	·900	·964	1·028	1·093	1·156	1·221	1·285	1·415	1·543	1·671	1·800	1·925	2·572	3·125	3·857	4·500	5·143	5·786	6·430	25

as that of economy, viz., that we should have $1\frac{1}{2}$ square inches per 1,000 ampères of current.

I pointed out that if you do not bury your conductors more than about two feet, the surface temperature is not affected; only the temperature of the conductor. If you go two feet deeper, you will affect the surface temperature also. I have thought that up to 10° C. is the limit endurable by foot-passengers. In the summer the rising temperature of the pavement is most objectionable; fortunately, this is the time when the current is the least used. Moreover, the temperature does not immediately pass through the ground. The daily variations of surface temperature differ as the diurnal change of position of the sun; it does not penetrate very deep down —is very slightly perceptible at two feet depth. If we have 500 ampères flowing for 24 hours, the effect would be almost exactly the same as if 1,000 ampères were flowing for six hours. Another point—instead of laying a sheet one centimetre thick, you might lay cables with the same result, provided the average thickness was one centimetre.

In speaking of the economical size of conductors, I arrived at the conclusion that I might use 2·7 inches, or say three inches for 1,000 ampères; but mark you, though 1,000 ampères is the average current, it is not the maximum current to pass through that conductor. The maximum is a very different thing indeed to that. When we have an average of 1,000 ampères, it does not in the least mean that that is the average quantity of current which is flowing through it, because the wasted energy depends upon the square of the current. This leads to a very different law, and a very important one, about which I have a word or two to say. Suppose n_1 is the number of hours during which a quarter of the lamps are burning, n_2 one-half, n_3 three-quarters, and n_4 the number of hours during which all the lamps are burning; then the ratio of average current to maximnm current is—

$$\sqrt{\frac{(\frac{1}{4})^2 n_1 + (\frac{1}{2})^2 n_2 + (\frac{3}{4})^2 n_3 + n_4}{n_1 + n_2 + n_3 + n_4}} = a.$$

The Table in the next column gives a for different values of n_1, n_2, n_3 and n_4.

Thus the average quantity can be got from the maximum quantity by multiplying by the correct value of a. If half the lamps are burning two-thirds of the time, and the rest of the time all the lamps are burning, we get $a = \cdot 5$. Therefore, instead of having 2·7, we only have 1·35 as the actual area of for 1,000

RATIO OF $\frac{\text{AVERAGE}}{\text{MAXIMUM}}$ CURRENT.

n_1	n_2	n_3	n_4	a
0	0	0	1	1·000
0	1	0	1	0·790
1	2	2	1	0·744
1	1	1	1	0·685
2	2	1	1	0·604
0	2	0	1	0·500

ampères. As a matter of fact, I shall select for the rest of the lectures ·5 as the value for a, and hence 1·5 square inches to the maximum current of 1,000 ampères. It seems to me, for a working hypothesis—which no one need adopt—a good enough value.

The third reason why we cannot reduce the size of the conductors too much is, that the potential falls, and the thinner the conductor, the greater the fall of potential between the dynamo and the lamps. With a large current there is a great fall of potential (experiment shown), thus showing that in a central lighting station the fall of pressure, and, therefore, the brightening of the lamps in the district, depends upon the number of the lamps in use at the time. This is a serious thing, and the most difficult engineering problem with which we have to deal. We have arrived at the consideration that a square inch and a-half for 1,000 ampères is the size we must use, which means a fall of potential of 1·6 volts for each conductor in every 100 yards, that is to say, a fall of nearly $3\frac{1}{4}$ volts, with the double conductor, for a distance of 100 yards; and whether you like it or not you must have it. It may be met by making distant consumers use lamps requiring a different pressure to those nearer. This is the thing which has given the most trouble, and the point will be considered in the next lectures.

I had hoped to have gone a little into a description of systems of laying mains which have been already adopted, but time is pressing too much. I will just say a few words abcut some of the systems I saw at the Philadelphia Exhibition last year. People seemed to have missed altogether the point that is to be aimed at in underground conductors. There was an invention shown, simply consisting of tiles with holes through them, the cables to go through the holes.

EDISON'S CONDUCTORS.

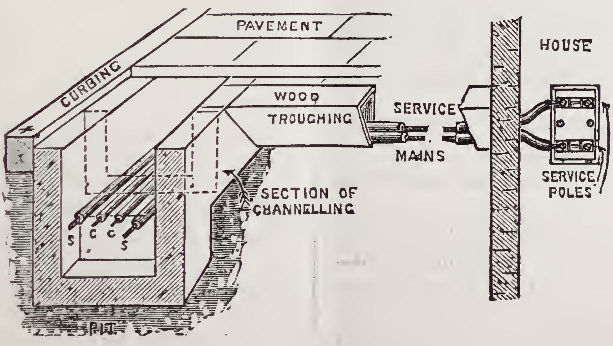
Outside in inches.	Area of one conductor in circular mils.	Maximum current in ampères.
3·5	1,639,890	1,400
3 0	862,976	760
2·25	262,951	370
1·31	107,289	220
1·05	33,000	100

These are laid in bituminous compounds in iron pipes, and seem to work pretty well for low potential work, but every electrical engineer thinks we shall be able to introduce high potentials some time or other, and reduce the cost of these mains.

What is it that makes it so difficult to insulate these mains properly? It is very difficult to say. It may be that there is a faint leak, and a spark passes to the iron pipe in which the conductors are encased, and that gives rise to an increasing leak. It may be that where there is the faintest leakage there is a partial decomposition of the water that comes into contact with it, and that brings electrolytic action into contact with the insulating material, which we know it generally destroys, and so the leak becomes worse, and very bad indeed. Through the kindness of the Brush Company, I have here a specimen of a fault in one of their underground City conductors showing where it is eaten into. In Philadelphia, there were some systems shown in which there was a very wide trough and glass plates introduced here and there, in which was a large number of holes. Glass is a very bad substance to use: it gets moisture upon it, and, besides, there is a tremendous wasting of space for small wire. In another, copper rods were carried through pipes made as water-tight as possible, supported on rings of glazed porcelain, so that there is a very small surface of leakage possible. With the rings here and there, of course, dampness was a serious obstacle; and in this system it was proposed to blow dry air through the pipes so as to keep the moisture continually out of them. I can only say of this that it is only a proposition; the thing has never been done.

I had hoped to speak to you of what has been done in underground conductors, but really there is very little to tell you, and that can be said in very few words. In Philadelphia, there was a system of underground conductors put down by the Excelsior Company, and they worked pretty well. They used large troughs, and where there are large troughs, there is no difficulty about it. But these large troughs had very serious inconveniences that one hardly expected from electricity. Three times during the time I was at Philadelphia the troughs in Chestnut-street blew up, a most unexpected result from an electric conductor, but it was a positive fact, and the secret was they were too near the gas mains, which leaked and positively filled the troughs, and, consequently, they blew up when a light came near them. However, these were accidents that might have been prevented with care.

I have an illustration here of the installation at Colchester, which illustrates the way in which very large troughs are laid with conductors cut along them.



CHANNELLING SHOWING CHARGING AND SUPPLY CABLES.

The Jablochkoff Company on the Thames-embankment has had a lengthened experience, extending since 1878, and with a small 7-16 strand wire, covered with gutta-percha and tape, and put in troughs underground, where it has given very little trouble. Then, again, in the City, the Brush Company has had these conductors underground since April, 1880, and they have had a great deal of trouble. They tell me that they were put in first very loosely, and covered with sand for some reason or other, and in drawing the cables through the pipes, the sand wore them away, and the consequence was the insulation went.

Among the most successful underground cables which I have seen are those used by the Indiarubber Company at Silvertown. The cables are numerous, and all made of copper coated with indiarubber, with a protecting cover of cold-drawn lead. These are laid in troughs underground, with frequent man-holes to assist in the insertion of new cables. Parts of these troughs are always full of water; other parts are always dry; elsewhere there are variations of wetness and dryness. An electromotive force up to 550 volts has been constantly used on most of these cables for several years, and although the insulation has varied with the weather, it has not in a single case been permanently injured, and I am informed that no repairs to the underground cables have been in any case necessary, nor have the man-holes been opened, except to lay down new cables.

With respect to the printed tables included in this paper, the following rules apply to the second one.

Rules for Finding from any Given Data the Size of the Mains Required.

Data required:—Annual cost of electrical horse-power and per-centage for interest and depreciation per annum, and cost of laying one additional ton of copper, the approximate size having been assumed.

Rule 1.—In Table II*b*. look down the column of cost for additional ton until you reach the given per-centage allowed. Take out the number there indicated.

Rule 2.—In Table II*a*. look along the line with the given cost of horse-power until this number is found. The number at the head of that column is the section per 1,000 ampères in inches.

Rule 3.—If this section be largely at variance with the approximate one selected, use now this value for a second calculation

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The number of visitors to the Exhibition for the week ending Tuesday, 29th September, was 119,478. Total since the opening, 3,017,154.

Obituary.

Cornelius Walford.—Mr. Walford, who was elected a member of the Society of Arts in 1857, died on Monday last, 28th ult., at his residence, Enfield-house, Belsize-park, South Hampstead. He was born in 1827, and was called to the bar as a member of the Middle Temple in 1860. He was a Fellow of the Institute of Actuaries, and a member of the Council of the Statistical Society. His practice was largely connected with insurance companies, and in 1871 he commenced his great work, "The Insurance Cyclopædia," which is still incomplete, although it extends to several volumes. Mr. Walford was a frequent attendant at the evening meetings of the Society, and joined in the discussions. On March 23rd, 1881, he read a paper on the "Increasing Number of Deaths from Explosions," and on February 28th, 1883, another, on the "Increasing Destruction of Life and Property by Fire." The list of papers read by him at the different societies with which he was connected would be a long one, and besides those of a specially statistical character, he wrote several on antiquarian subjects.

Walter Weldon, F.R.S.—Mr. Weldon, the eminent chemist, died on Sunday, 27th September, after a short illness, said to be caused by overwork. His most important invention was a process for the recovery of the manganese used in the manufacture of chlorine, respecting which process he read a paper before the Society of Arts, on May 22, 1874. By this process he saved nearly £6 on every ton of bleaching powder made, quadrupled the total manufacture, made the industrial world the richer by some three-quarters of a million sterling per annum, and, as the French chemist Dumas publicly observed, "cheapened every sheet of paper and every yard of calico made in the world." Mr. Weldon was a Chevalier of the Legion of Honour, and one of the five men (the only foreigner) whom the French Société d'Encouragement has deemed worthy of its "grand medal." He was elected a Fellow of the Royal Society in 1882, and a member of the Society of Arts in 1874. On several occasions he presided at meetings of the Society.

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Proceedings of the Society.

CANTOR LECTURES.

DISTRIBUTION OF ELECTRICITY.

By Prof. George Forbes.

Lecture II.—Delivered February 9th, 1885.

In my last lecture, I introduced to your attention the elementary principles which must guide the engineer in the selection of the right size of mains to use. These principles maintain whether it be a private installation of the electric light or a large supply from a central station. But, in the future, I shall confine my remarks chiefly to the latter class. In whatever manner the mains be laid down, the mass of copper contained in them is very large, and their establishment constitutes a large portion of the prime cost of laying down a system of central station lighting. For 100,000 Edison lamps we require over a ton of copper per yard run, and everyone knows how rapidly the number of miles of mains mounts up, even in a small district, owing to the large number of side streets.

Now, when a bridge like the Forth or the Tay bridge, or the Brooklyn bridge at New York, is designed, the engineer spares neither time, labour, nor expense, in his preliminary calculations of the weight of metal required in the several parts to combine strength with economy. In such bridges the mass of metal is enormous, and the reduction of cost in this item is very important, independently of the fact that, within a certain limit, the less metal there is in it the more efficient is the bridge. Consequently, the proportions of the different parts must be most carefully calculated by the ablest mathematicians.

Now, I maintain that exactly the same care should be taken in the estimation of the proportions of different parts of our electric mains. It is a point which has been sadly overlooked in the past, even by some of the most advanced and far-seeing of electricians. But when we consider the enormous amount of capital which must be sunk in mains, I hope that engineers will see how intensely important it is to spare neither trouble nor expense in preliminary calculation in order to ensure the best result.

Now, in the present state of electric lighting, economy is of primary importance. Judging by the experience of the New York central station for electric lighting, we should be prepared to deny the possibility of economically furnishing the electric light to the British public. I, however, do not hold this view. I see several defects in that example of electrical distribution. The dynamos are of an expensive kind, and the outlay in this matter has been excessive. Moreover, the mains are laid on unsound principles, and are both expensive and, I believe, unsatisfactory. The general scheme for an installation is not to be written down casually on a few sheets of paper; it requires weeks, or even months, to prepare the estimates, and to calculate the requirement of any such central station. I have no doubt the defects that I have alluded to are due largely to the early period at which that station was designed. But even in later estimates, and in our own country, I have seen the want of that detailed calculation which can alone lead to economy.

In any system, at the present time, economy is the main thing to be considered in designing a system of distribution. Other difficulties, such as equalisation of potential, must be looked upon as difficulties to be faced and conquered by the engineer.

In my previous lecture I have given you three reasons why we must not try to economise too much by laying very thin conductors.

1st. It is not economy, on account of the wasted energy in heating the conductors.

2nd. The conductors may become so hot as to injure insulation, increase the resistance excessively, and even be uncomfortable to the foot passenger.

3rd. The fall of potential over a district, and the variation of the potential at each point of a district, are both increased by thinning the wires.

I showed that, by due selection of the method of laying mains, the second can be reconciled with the first, which thus becomes paramount, leaving the third to be overcome by the engineer as best he can.

I showed you the general principles which must guide us in the economical selection of the size of mains, and I gave you some tables which, I trust, will be found of great value to the engineer. Nothing is there chosen for him. He may put his own price on the cost of an electrical horse-power and on the cost of laying mains. In any special case, and in all parts of the scheme he is designing, these tables give him, almost at a glance, the economical size of main he must employ. He can then, by the aid of my formulæ, determine approximately the rise of temperatute under different systems of laying, and he will see whether these mains may be laid in a single conductor of circular section, a flat sheet of definite thickness, or a series of cables side by side.

Then comes the question of equalisation of potentials, which we shall have to deal with very fully in this and the following lecture.

I shall now, by way of introduction to what follows, lay before you the principal diverse systems which have been proposed, and shall afterwards examine each in detail. These are five in number, varying either in the way the lamps are connected with the main, or in the introduction of some special appliance. They are as follows :—

1. Multiple arc.
2. Series.
3. Multiple series.
4. Accumulators.
5. Secondary generators.

Some of these have a large number of subheads. I shall confine myself to-day to the first class, as being at present the most important. It will be convenient to subdivide this system into several classes, which I venture to name as follows :—1. Parallel line. 2. Reversed parallel line. 3. Network mains. 4. Tree mains. 5. Multiple tree mains. 6. Independent wire mains.

Lamps in Series.

The oldest propositions for electric lighting had no reference to multiple arc. It was proposed to put all the lamps in series. This method economises largely in the cost of mains, but the number of lamps which can be supplied is very limited. The pressure required for lamps in series is greater than for lamps in quantity or multiple arc, in proportion to their number. The hydraulic analogy to electricity is always instructive. Now a lamp is represented by a water-engine or turbine giving off a certain amount of energy; a certain difference of pressure between the inlet and outlet of the water-engines is required to give off this energy. If, now, the outflow goes into a second water main, which again feeds a second water-engine, these engines are in series, and the pressure which must be supplied is exactly proportional to the number of engines placed in series. If the water-engines were all put upon the same main, the pressure required would be the same as for one, but the volume of water required would be greater than for one, exactly in proportion to the number of water-engines. Moreover, the size of pipe must be increased to allow this larger volume pass without too much resistance from friction of the pipes.

These hydraulic facts, so simple and self-evident, are the exact analogues to facts in electric lighting. If lamps are in series, the electric pressure must be increased in proportion to their number. The electric mains supplying many lamps in multiple arc require the same pressure as for one lamp, but the size of the mains must be increased to prevent waste of energy by their resistance to the electric current.

Thus, if we have ten lamps in series, the current is one-tenth of what is required for ten lamps in multiple arc, and hence, on the economical considerations, the copper mains may be about one-tenth of the sectional area.

But the number of lamps which can so be put in series is limited. The highest potential which has been used hitherto, so far as I am aware, is 5,000 volts, and some people will say that even this is dangerous. I do not hold this view at all. If, as in America, a line be properly insulated, and if it be tested once or twice a day at the dynamo-house, there is no real danger to consumers; and if, as in America, the workmen at the dynamos wear india-rubber gloves or the homely golosh, there is no danger for them. I have no hesitation in asserting that the dangers from high potential electricity are far less than those from gas. Hardly a week passes but we read of dreadful explosions of gas. Suffocation is not uncommon, and in the first days of gas, when ignorant people often blew out their light, it was a dreadfully common occurrence.

If, now, we have 5,000 volts, and consume

100 volts in each lamp, we can only put 50 lamps in series. But, on the other hand, if such a system were to be adopted, it would be desirable to use lamps of much lower potential. When talking of the multiple arc system, I said it was desirable to use lamps of as high a potential as possible to economise the mains; so here I say, in a series system, we must use lamps of as low a potential as possible, so as to economise pressure. If we could have 20-candle lamps of 2 volts, we could work 2,500 lamps off a single wire with 5,000 volts (neglecting the resistance of leads). Assuming 3 watts per candle-power, this would mean a current of 30 ampères. In many cases this would be a highly economical system of distribution. There are, however, two objections to this plan which I look upon as fatal.

If one lamp is put out of circuit, it puts out all the other lamps. Consequently, the switch for a lamp must be one which will short circuit it, just as the plugs of a resistance box cut out resistances by short circuiting them. Then the engine-driver must regulate his dynamos so that the current is constant. Automatic adjustments have been made for this purpose with arc lamps, and their action is excellent. These are to be found in all American arc systems, and are a great point in their favour. If, however, the filament of a lamp breaks, all the other lamps in the series go out also. It would be necessary to have an automatic arrangement to short-circuit a lamp when its filament broke. This is no easy matter, and could hardly be done without a local battery, or a second wire from the dynamo. In any case, the introduction of any such apparatus into each lamp would add to its cost and liability to get out of order.

It may be said, however, that with the thick low-resistance lamps of 2 volts ($\frac{1}{15}$ ohm), they would not break, but would be changed long before they got thin enough to break. In this case, however, the second objection is fatal.

The second objection is that with such thick filaments for lamps, it would be impossible to get anything like a candle for three watts. I think it was in 1874, when the Russian Logodine showed his incandesent lamps of thick carbon, that I tried some experiments at Anderson's College, Glasgow, where I was then Professor of Natural Philosophy. These experiments convinced me that incandescent lamps of that kind could never be economical. The heat carried away by the terminals was so great as to waste a large part of the energy put into the lamp. This is the objection which I have to the Bernstein lamp. I shall never forget the astonishment with which I first saw one of Mr. Swan's lamps with a thin filament. My astonishment was at seeing the filament glowing white up to the terminal. This can only be done to perfection by a lamp of very high resistance.

I remember seeing an able man of science showing some of the small fairy lamps to a scientific audience, and he asserted that its efficiency was doubtless the same as the 20-candle lamps, "because it is made of the same material." This was a serious misstatement.

I think enough has been said to convince you that, although in some cases, this system may be worthy of consideration, it is not generally applicable. If the lamps are of low resistance they are not economical. If of high resistance we have few in series, and require a special device to short circuit a lamp when the filament breaks.

It would not be well, however, to leave this system without pointing out to inventors that it has one more advantage as compared with the multiple arc system. Our present lamps (designed for multiple arc) have a serious drawback compared with gas. You cannot lower them to give less light. Even if these were a means of reducing the current through them you would not get economy because of the lowered temperatnre. Now with the series arrangement it is conceivable that the filament might by some means be lengthened and shortened, and since the current is constant, the brightness would depend on the length, and all lengths would be equally economical except for the absorption of heat at the terminals. I do not wish to invent, so I will say no more.

In America, arc lights are seen in series, sometimes to the number of 100. One cannot help feeling pleasure either in seeing the dozens of dynamos at work in the central station, or in admiring the graceful curves of overhead wires, well insulated, and supported on well-shaped steel poles, as in Philadelphia, and in seeing the bright light which they are spreading over seventy miles of street, and with which they are gladdening the hearts of thousands. In some systems, with ten ampères flowing, an arc lamp is replaced by ten incandescent lamps in parallel, each using an ampère, and with switches to substitute resistances for lamps.

Mains with Lamps in Multiple Arc.

I think it may be fairly assumed that a 16 or 20 candle-power lamp is what is most likely to be generally adopted. It is found that we can get one candle-power for an expenditure of three watts of work. Now this three watts is the product of the current and the pressure, and may be made up in a variety of ways. We may increase the ampères of current, and diminish the volts of pressure, or *vice-versa*. So far, however, as economy of mains is concerned, there is no doubt what is the best course to follow. The smaller the current, the smaller are the mains. Hence it is clearly desirable to use lamps of a high potential—100 volts is at present about the limit that is used—but I am informed by Mr. Swan that equally good lamps could be made of 400 volts if there were a demand for them. There is at present an absurd regulation of the Board of Trade limiting the pressure in houses to 200 volts ; but, I think, we may take it for granted that more enlightened views will ultimately prevail. If such lamps were used, the cost of mains would be reduced to about one quarter, which is, of course, a very great step.

Here, then, is a step which, according to the information before us, can be taken at once. Why it is not taken I am at a loss to understand. If lamps of 20 candle-power can be made with a long life, using 400 volts and ·15 ampère, the question of central station-lighting on economical principles is advanced enormously. The inventors and manufacturers are alone to blame if, by delaying to take this step, they hinder the adoption of this system of lighting.

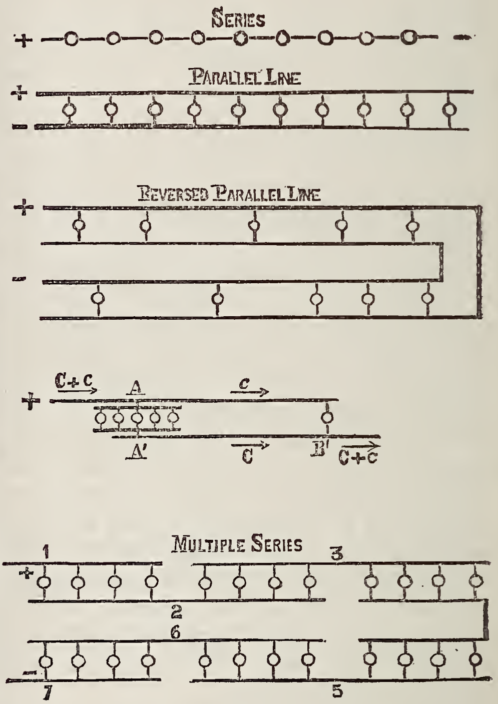
These remarks apply, more or less, to nearly all the systems of distribution, but especially to the multiple arc system, where the mass of copper in the mains is so great.

Now let us look at the simplest distribution, where we lead mains along a single street, and take off the current at various points, using each such point as a source of supply to a house, or it may be to a whole district.

The diagrams below show different systems of aying the mains. In the single parallel line it will be noticed that the potential falls off as we go farther from the station. If the size of conductor is proportioned to the current with $1\frac{1}{2}$ square inches per 1,000 ampères of maximum current, the fall of potential is regular, and amounts to 3·22 volts per 100 yards of double conductor when the maximum number of lamps are in use.

This is a good opportunity to draw attention to a point which meets us in studying nearly every system of distribution. Since the size of conductors is proportioned to the current, they are abruptly diminished in section at each point of consumption. It follows that, so far as weight of copper is concerned, this system is equivalent to one in which separate wires all of the same size go from the central station to each point of consumption.

The difference between these two plans—(1) the massive main system and (2) the independent wire system—consists in this, that



while their action is identical in reducing the pressure when all the lamps are lighted, their action is different when some lamps are extinguished. With the independent wire system, the conductors leading to points of consumption not in use lie idle. In the massive main system the equivalent mass of metal is used, under the same conditions, to diminish the resistance of conductors to the points of consumption which are in use. This would seem at first sight to be all in favour of the massive main system; this, however, is by no means sure. If only the nearest and most distant points of consumption were in use, and R be the resistance of mains between these points, V the pressure at the near point, and r the resistance

of lamps at the far end, the energy used up by the distant lamps and the mains to them is $\frac{V^2}{R+r}$. The current is $\frac{V}{R+r}$. R is greater for the independent wire system than for the massive system. Hence the current and energy used are less with the former than the latter system. Moreover, since the current is less, r is greater. Hence, *à fortiori*, the energy used with an independent wire system is less. In fact, with the massive mains, the distant lamps will be far too bright. If, however, the fall of potential with the maximum current is only a few volts, this would not be important. The system of independent wires takes away from the inconvenience of varying pressure at definite points of consumption. It seems at first sight to be ridiculous to think of having a separate wire to each lamp from the central station. But it is by no manner of means ridiculous. In fact, it is well worthy of serious consideration.

In a previous part of the lecture I have shown what loss of energy we must allow in the leads and other conductors. Now this loss of energy shows itself by a fall of potential. If δV be the difference of potential between two points of a main, R the resistance between these points, and C the current, then $\delta V = CR$.

Now, I have resolved to assnme in these lectures a section of $1\frac{1}{2}$ square inches per 1,000 ampères. The resistance of 100 yards of a copper conductor of this section is ·00161 ohm, and $\delta V = 1{,}000 \times \cdot 00161 = 1 \cdot 61$ volt. That is, we have, with such a conductor, a fall of 1·61 volts in every 100 yards of single conductor, and a fall of 3·22 volts per 100 yards of double conductor. This takes place when the maximum current is being used. With a smaller current the loss is less. With 500 ampères to the $1\frac{1}{2}$-inch conductor, it is only 1·61 volt, and with 100 ampères or less it is nearly inappreciable.

Now, while it is very satisfactory to the engineer to find that with small currents there is so little waste of energy, still there is a counterbalancing disadvantage of serious importance, I may say the most serious importance, in considering the question of laying mains. [In the following remarks I will assume that the engine is perfectly governed.]

Suppose there is a distance of 500 yards between the engine-house and the farthest lamps, and that lamps are being supplied all the way along, and that the conductor is properly proportioned to the current, on economical considerations, at every point. Then while the maximum number of lamps are in use, those nearest to the engine-house have an electrical pressure 16·1 volts higher than those farthest from the engine. Well, this might be counteracted by causing the consumers at a distance to use lamps of 16·1 volts lower potential. That is all very well while the maximum current is flowing. But when the number of lamps is reduced one-tenth, the difference of pressure to the two consumers is only 1·64 volts. Thus, if the nearest consumer has a constant pressure, the distant one has his pressure varying by 14·49 volts. It is true that in this case we might vary the pressure at the engine-house, so that the near consumer was 7·25 volts below, and the distant one 7·25 volts above his normal pressure; but even these variations are very serious. A variation of 7·25 volts in the potential of lamps is a most serious matter, even if we look at this variation as being only 3·62 volts above and below the pressure for which the lamp is constructed. To illustrate this, I will give you three curves on a diagram. The first shows how the candle-power is affected by the pressure; the second how the life is affected by the candle-power; and the third, how the life is affected by the pressure. The first is Mr. Edison's table of 1883; the second is from the experiments of Mr. J. Zacharias; and the third I have deduced from the tests of Woodhouse and Rawson lamps at the Vienna Exhibition. Generally, in 100 volt 16-candle lamps, a volt makes a difference of a candle.

I will now show you, experimentally, the fall of potential along a main. I have three lamps of equal brightness; when I connect the two at opposite ends of my main, the distant one is much feebler than the near one. If I insert a third half way, the distant one falls still more, because the main has to take more current. [Experiment.] This is one of the most serious problems which have to be considered in engineering the mains of a central station, and a large portion of this course of lectures will be devoted to the devices which have been proposed for getting over the difficulty.

I have next to describe to you the different systems of connecting the lamps of consumers with the engine-house. In the remarks which have gone before, I have confined my illustrations mainly to a multiple arc system; but there are several others, each of which has certain advantages.

With the massive main system it has some-

times been proposed to equalise the pressure for lamps over a district by putting in proportionate resistances at the points of consumption. It has also been proposed to prevent variation of pressure when the consumption varies, by making these resistances adjustable automatically. This, however, must not for a moment be thought of. I pass over the fact that automatic adjustable resistances have generally been a failure, because the designers are alone to blame for this; but I do insist that an economical system of working is incompatible with the free use of resistances in the working circuit, which use up a large quantity of energy. It is better to use lamps of different qualities in different parts of a district than to introduce such resistances, and the engineer must find some other means of dealing with the variations of pressure with varying consumption.

The remarks I have made about the independent wire system must be looked upon as parenthetical. We shall recur to the subject. We have now examined the single parallel line, and have seen that, so far as weight of copper is concerned, it is equivalent to a separate wire to each lamp. We have also seen how the pressure falls off as we go from the station.

The reversed parallel line (Fig. p. 1042) was devised to prevent this fall of pressure. Two wires run side by side; one end of one wire is attached to the + pole, and the other end of the other wire is attached to the — pole. Thus the current supplying each lamp goes around the whole circuit, and so there is a tendency to equalise the pressure for all lamps. In the diagram the wires are shown of taper form, but they have been generally taken to be of uniform thickness. It has been shown by Professor Ayrton that, in this case, the pressures are not equalised if a larger current is taken off at one point than another.

Suppose at point A a large number of lamps is supplied, and at B a small number, so that a current C passes through the lamps at A, and a current c through those at B. Let R be the resistance of A B or A′ B′. The fall of potential from A to B is cR, and from A′ to B′ it is CR. Hence the pressure at B is greater than at A by the quantity $(C - c)$ R; *e.g.*, with 500 lamps at A and 10 lamps at B, and 0·75 ampères per lamp, and with A B = 200 yards, and resistance = ·0032, the fall of pressure is 1·17 volts.

Mr. Kapp (*Electrician*, May, 1883) has gone further, and shown that with lamps equally distributed over the whole line, the middle ones have less pressure than those at the two ends.

But it must be noticed that if at each point the section of conductors is made proportional to the current, then the quantity $CR' = cR$, and the fall of potential to both terminals of a lamp is the same, where R R′ are the resistances of A B and A′ B′ respectively. If the size of conductors be properly proportioned, the pressure is constant at all points of the line. Now what does it mean to make the section of conductor proportional to the current? It means that, so far as weight of copper is concerned, it is equivalent to having a separate wire for each lamp going round the whole circuit. Here is the weak point of the whole system. Equalisation of pressure is attained by putting in useless resistance. The wire might go up to the lamp, and then back to the dynamo, without making the whole circuit, and equalisation of pressure attained by putting in a resistance at the lamp equivalent to the copper wire which has been cut out. Such a resistance could be made of much cheaper material than copper. Thus the reversed parallel system, beautiful at the first glance, is the same in efficiency as, and inferior in economy to, the direct parallel system, with resistances in the lamps to equalise pressure.

It seems to me that this consideration is absolutely condemnatory of the reversed parallel system for application to mains. It is worse than the direct parallel system with resistances introduced, and we have already condemned the latter. It becomes then hardly necessary to speak of it further, but a somewhat similar arrangement may be used with multiple series systems. I cannot refrain from pointing out to you a device by means of which the equalisation of pressures might be maintained, even when the maximum number of lamps is not in action. In this case the proportion of the + and — conductors should be altered in some parts. Suppose the conductors to be made up of a number of insulated wires in sections, and that at each end of a section each wire is attached to the + bundle, or the — bundle of wires. It would be easy to design an arrangement by which these terminals could be changed from the + to the — bundle, or *vice versa*. It would also be easy to design an automatic switch by which, when the size of the + and — mains was not proportioned to the currents in them, the two terminals of one or more wires should be so transferred from the bundle which is too great to the one which is too small.

We have now reached the most important and difficult part of the problem. Leaving behind the case of a single street, we come to a district. In the choice of districts to light, care should be taken in the selection of those which will give the best return for outlay of money and cost of maintenance. It is needless to say that a district with many theatres and restaurants is favourable, and that many storeyed houses have a larger consumption for a given area than a district of low houses. The first thing to be done is to estimate as well as possible (and it is not possible to be exact) the number of lights to be supplied in each part of the district. The only alternative to this method would be to lay mains large enough to supplant gas entirely. This would involve a great outlay in mains which for years would generally be lying useless, or at most diminishing in a feeble degree the cost of wasted energy. It is quite right that the engineer should calculate the cost of mains on these lines, but in general it could not be recommended to spend so much money on laying them. It is generally better to trust to laying additional mains as required.

Tree Main.—First let us suppose that we have all the mains connected in parallel with all the dynamos. This is a case which I find has been well discussed by Mr. Kapp in *The Electrician*, August 4, 1883, but it is a system which we shall soon find reason to condemn. The reason why I object to this system is that the size of mains is not made dependent on considerations of economy, but on that of variations of pressure allowed by the Board of Trade. This must be the case with the above mode of working, if the district is large. The difference of potential between the near and distant lamps is insensible when there are few lamps burning. The difference when the maximum number of lamps are burning is considerable. Hence, if the near lamps are kept at constant pressure, the far lamps will vary at different times by the amount of the difference between the near and far lamps, when all are on. Now, the Board of Trade forbid a greater variation than 10 per cent. (5 per cent. up and down). Hence the maximum difference of pressure between near and far lamps must not exceed 10 per cent. Here I may say that 10 per cent. is a far greater variation than is permissible. Two or three per cent. up and down is quite as much as can be allowed. Now, Mr. Kapp assumes the size of conductors to be limited by these considerations. He assumes the maximum difference of pressure between the nearest and the farthest lamp to be the maximum which can be allowed. On this view notice the following facts:—

1. If we have two similar areas, with equal number of lamps to light, one larger than the other, the mains in the former must be so increased as to make the fall of pressure to the most distant lamps the same in both. Hence the section of mains is proportional to R, this maximum distance, other things being equal, and their length varies as R, so the cost varies as R^2.

2. The section of mains varies as n, the number of lamps.

3. The section of mains depends in two ways on the pressure required for a lamp; (α) the current and section of mains are less in proportion to the pressure; (β) the variation in pressure allowable (being a per-centage) is proportional to the pressure. Hence, on the whole, the section is inversed, as the square of E, the electric pressure of a lamp.

4. The section of mains varies inversely as p, the per-centage variation of pressure allowed.

On the whole, the section of mains, and the cost of mains (assumed proportional) vary as follows—

$$\text{Section varies as } \frac{n\,R}{p\,E^2}$$

$$\text{Cost varies as } \frac{n\,R^2}{p\,E^2}$$

Mr. Kapp has deduced a coefficient from actual estimates and finds—

$$\text{Cost in pounds} = 0{\cdot}9 \times \frac{n\,R^2}{p\,E^2} \text{ or } 1{\cdot}2\,\frac{n\,R^2}{p\,E^2}$$

where R is given in 100 yards, and E in 100 volts, according as the most favourable or the least favourable of likely distributions is adopted. [The co-efficient 1·2 is used for equal distribution of lamps, and 0·9 when the number of lamps at distance r varies as $\frac{1}{r}$.] To take an example where $n = 60{,}000$ lamps, $R = 7$ (hundred yards), $E = {1{\cdot}00 \atop 1{\cdot}40}$ (hundred volts), $p = {4 \atop 10}$ $\left({2 \atop 5}\right.$ per cent. up and down).

$\therefore$ Cost is between ${£661{,}500 \atop £135{,}000}$ and ${£882{,}000. \atop £180{,}000.}$

If we used lamps of 420 volts, the cost would lie between £15,000 and £20,000, instead of the lower pair of figures. But these figures are of no value; first, because 10 per cent. is too great a variation of pressure; and, secondly, because the economical size of mains is the primary consideration, and

we must find a way out of the difficulty of variations of pressure.

We must now consider to what distance we may use the method of connecting all the mains, and charging them all with the same dynamos. I think we may say that 2 per cent. variation of pressure up and down is permissible. This gives a variation of four candles in an Edison 16-candle lamp. Now, by attention to the dynamos, this allows a range of 4 per cent., all lamps in the district requiring the same pressure. If telegraph wires came from the most distant and nearest lamps to the engine-house to indicate on voltmeters the pressure at those points, the engineer would have his instructions to keep the near lamps as much above the normal pressure as the distant ones are below. Suppose that 100 volts is the normal pressure. When very few lamps are on, both near and distant mains would indicate 100 volts. This is the case where metal is laid for a large number of lamps, even at the distant points, and in any actual installation it may be taken to be approximately accurate. When the maximum number of lamps are on, there will be 4 per cent. difference. The engineer keeps the near lamps at 102 volts, and the distant ones at 98 volts, and we have only a 2 per cent. variation. If, however, the near lamps be supplied with 102 volt lamps, and the far ones with 98 volt lamps, it will be seen that we can double the distance, with of course double the fall of pressure, giving 8 per cent. variation, with only 2 per cent. variation up or down in any lamp. For when few lamps are on, the near and far lamps have the same pressure. The engineer makes this 100 volts, which is — 2 per cent. for near lamps, and + 2 per cent. for far lamps. When all the lamps are on, the engineer makes the near lamps 104 volts, or + 2 per cent., and the far lamps 96 volts or – 2 per cent., giving a difference of 8 per cent., and doubling the distance which can be supplied. This method has the advantage of not always using the near lamps above, and the far lamps below, their normal pressure; but I must confess I do not like the idea of supplying different consumers with lamps of different pressure, if it can be avoided without loss of economy.

We have now to consider at what distance from the central station we may supply lamps, so that the fall of potential does not exceed 4 per cent. or 8 per cent. This depends on the pressure required for lamps, and on the size of conductors chosen per 1,000 ampères. Every engineer in designing mains must fix on these points for himself, but in order to fix our ideas, I will take the case of 100-volt lamps, and $1\frac{1}{2}$ sq. in. per 1,000 ampères.

With that size of conductor the loss of pressure with the maximum number of lamps is 3·22 volts per 100 yards of double conductor; 4 per cent. is lost in a distance of 124 yards, and 8 per cent. in a distance of 248 yards; so that this is the greatest distance of a lamp from the central station (according as we supply lamps of the same or different normal pressures to different districts) which is consistent at the same time with economical size of conductors, and with a maximum variation of 2 per cent., up and down, in the pressure supplied to any lamp.

From what has been said, it will be seen that in this way of working, the pressure at the station must be constantly regulated, either by the speed of the engines, or by introducing resistance into the field magnet coils. I prefer the latter method, unless the newly invented electrical governors (such as Willans') prove a success.

The above considerations apply to what I call the tree system of laying mains. The trunk of the tree starts from the engine-house, and throws off branches, from which twigs spring, and leaf stalks from these, and the lamps are represented by leaves. The above considerations do not apply to cases where feeder mains go from different dynamos, or generally where the pressure in different mains at the station is different.

It appears, then, that the tree system is of limited application under the conditions which I assumed, the maximum distance being 248 yards. If, however, we had lamps of 400 volts, the maximum distance (measured, of course, along the line of leads) would be 992 yards.

In the tree system we must lead our conductors along the shortest route from each lamp to the central station, and then count the number of lamps supplied, and so determine the section of copper required by each point of the mains. If we connect the ends of the positive twigs and the ends of the negative twigs, we do not alter the flow of current when the maximum number of lamps are on, if the size of mains is chosen for this maximum distribution; but when the consumption is limited, we consume a little more energy in proportion, and the distant lamps are a little brighter. But, considering the uncertainty of estimating the relative consumption in

different parts of a district, the distant lamps will probably be better served if the + twigs are joined together, and so with the — twigs.

I wish to repeat the statement that, in the tree system, the amount of copper in all parts of the mains is the same as if a separate wire came from every lamp to the station. As a consequence, the engineer must notice that if a plant has been laid down for a certain number of lamps, and it be afterwards desired to extend the boundary of the district, the conductors already laid down are of no use in leading current to the beginning of the extended district. The conductors must be enlarged, or else new mains must be led to supply the newly-added district. The engineer must also use his influence strongly to prevent the natural tendency to take a larger number of lamps in a district of supply than that for which the conductors have been calculated.

It must be acknowledged that the simple tree system, where all the dynamos are connected in parallel with the mains, presents a very serious obstacle in the rapid fall of potential, the maximum distance of a lamp from the station along the line of conductors, consistent with the economical considerations, being 124 yards, if the pressure required for all lamps is the same. In the year 1880, Mr. Edison took out a patent in England (No. 3,880), besides other countries, in which he gets over the difficulty by using what he calls feeder mains. It is a result which would certainly have been arrived at by any one who thoroughly and intelligently worked out the problem. But, so far as I can discover, he was the first, by a long time, to hit upon this cure for the evil; and I must say that it is interesting to find how thoroughly he had gone into the problem at that early stage of electric lighting, although, in a patent of slightly earlier date, he describes the tree system as being all that is required for electric lighting, and does not notice the fact of fall of potentials as affecting the problem.

In the patent cited above, Mr. Edison gives, among other irrelevant matter, two solutions of the theory which I may call the multiple tree system and the network system of laying conductors. I will not follow him in his method of using these systems in practice, because he does not use them to the best advantage. In this case, as heretofore, I will advance with you, by common-sense arguments, to the more perfect types.

Multiple Tree System.—I will assume that all lamps are of the same pressure. In this case, the size of conductor per 1,000 ampères being fixed, 124 yards is the limiting length of conductor. Now notice that this is not necessarily the limiting length of conductor from the station, because it does not much matter what the fall of potential from the station to a lamp is; but it is the limiting length of conductor between the farthest and the nearest lamp, or the difference in length of conductor to the station from the farthest and nearest lamps; for here the injurious variation of potential comes into play. If the nearest lamp were 124 yards from the central station, there would be a loss of potential of 4 volts in that distance, in order to comply with economical considerations, but that loss of potential would not affect the potential between different lamps, if the engine driver regulates the pressure by telegraphic indications of the potential at the nearest and farthest lamps. Compensated galvanometers may be introduced in the engine-house to indicate the potential of distributing boxes, when variable currents are flowing.

Our first tree system extends to a distance of 124 yards; beyond that we must have a second tree system with feeder mains to a distributing box, from which branches go out to supply a district, no part of which is more than 124 yards from the distributing box, or less than 124 yards from the station. From these distributing boxes a pair of thin wires might go to a voltmeter in the engine-house, an end of each wire being attached to the mains in the distributing box. With a similar tell-tale coming from the most distant lamp of the system, the engineer knows exactly what pressure is required. This second district, with feeder mains losing 4 volts, is generally larger than the first, and will generally require a number of feeder mains, or roots, feeding separate trees. It will be noticed that each root is connected to a separate dynamo.

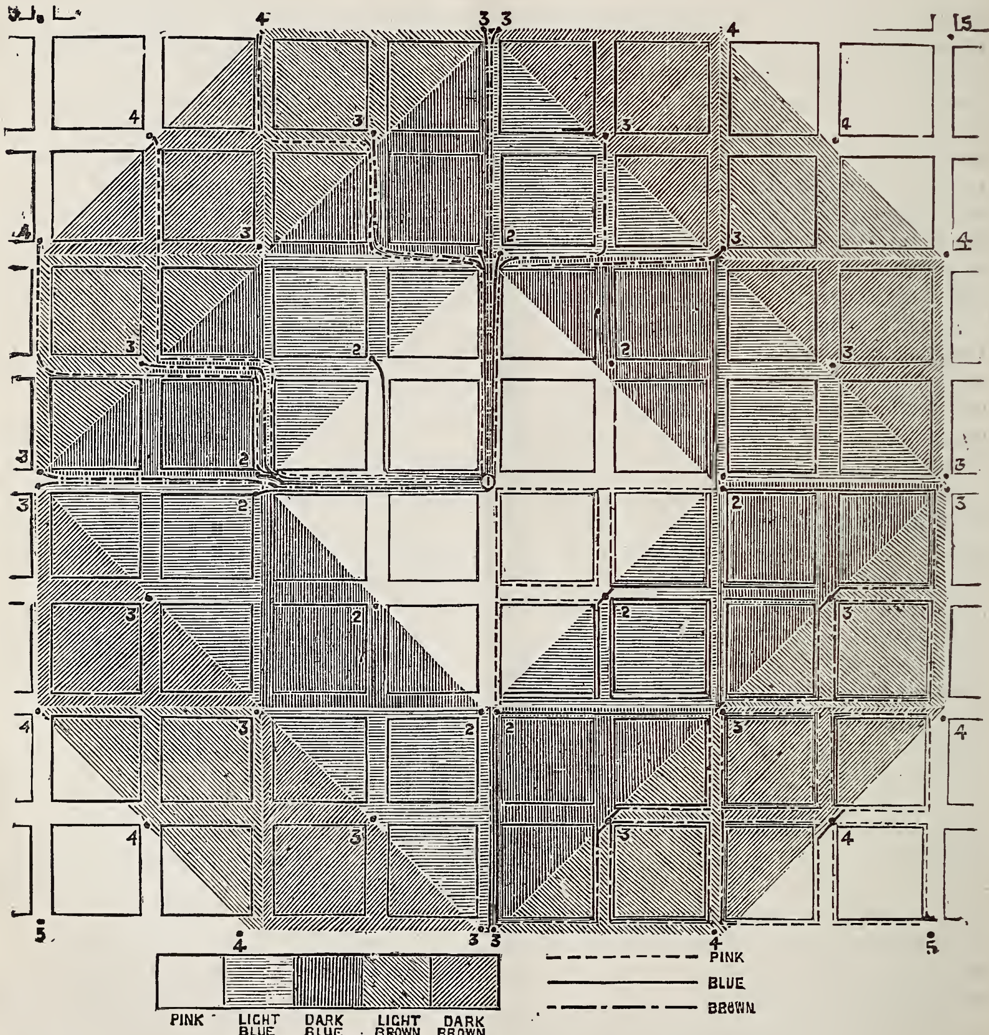
If we extend the distance still further, we must put on a new set of roots or feeder mains, each losing 8 volts; and so on up to any distance. The further we go, the greater is the cost of mains, but this cost is more nearly in proportion to the distance than to the fourth power of the distance, as in Mr. Kapp's paper (which is not founded on the economical considerations).

I must here put in a warning, necessary from what I have seen of the practice of this system here and abroad. The distributing box of a feeder must not be in the centre of the district

supplied by that feeder, or you waste all the extra copper going to the lamps nearer to the station than the distributing box. The point of distribution must be the point of the district nearest to the central station, in order that we may have a maximum economy of copper.

Suppose we are lighting a town like Philadelphia or Chicago, which is built in square blocks, and suppose two sides of each square are 124 yards long, we should have a fed centre for each block on the diagram below where 1 is the central station.

Within the square indicated by the figure 1 no feeder mains are required. The distance of all the points 2 from the station is the same if measured along the streets. There



are four squares and eight half squares thus snpplied, equivalent to eight squares. The first feeder main supplies the district between the squares marked 2 and 3 respectively, equivalent to twenty-four squares; the second set of feeders supply forty squares, the third fifty-six, and so on. The copper in the service of a block is one-half of the copper in 124 yards of the feeder main for a block, since some supply conductors are short, and others 124 yards long. Thus, to supply twenty-four squares with the first feeder, the latter must have the copper of supply conductors for forty-eight squares. In this way we find the cost of supplying the districts up to 1, 2, 3, &c. Let L be the cost of copper for one square:—

Cost for district 1 is		8L	for 8 squares.
,, between 1 and 2 (supply)		24L	
,, ,, (feeders)		48L	
Cost of district 2		80L	for 32 squares.
,, between 2 and 3 (supply)		40L	
,, ,, (feeders up to 2)		80L	
,, ,, (from 2 to 3)		80L	
Cost of district 3		280L	for 72 squares.
,, between 3 and 4 (supply)		56L	
,, ,, (feeders up to 2)		112L	
,, ,, (2 to 3)		112L	
,, ,, (3 to 4)		112L	
Cost of district 4		672L	for 128 squares.

The cost of lighting a square up to distance	124 yards is	L	per square.
,, ,,	2 × 124 ,,	2·5L	,,
,, ,,	3 × 124 ,,	3·8L	,,
,, ,,	4 × 124 ,,	5·25L	,,

It will be seen, then, that the cost does not, in this system, vary in a proportion even approaching the fourth power of the distance, but is much more nearly proportioned to the distance, especially when we go to great distances. The following Table compares the cost of lighting districts of various sizes with and without feeders and distributing centres:—

	No. of squares.	Cost with feeders.	Cost without feeders.	No. of lamps.
1 district	8	8,000	8,000	1,600
2 districts......	32	90,000	128,000	6,400
3 districts......	72	280,000	648,000	14,400
4 districts......	128	672,000	2,048,000	25,600

The system which I have now described is nearly the same as that which was proposed (in an imperfect form) by Mr. Edison in 1880. In 1883, Mr. R. E. Crompton proposed a somewhat similar arrangement for the Victoria provisional orders (also imperfect). As shown before, telegraph wires from distributing boxes (proposed by Mr. Edison) are unnecessary; a compound-wound galvanometer attached to the mains in the engine-house serves the same purpose.

I would draw attention to the fact that the ends of the twigs, or the branch conductors, in parts of a district fed by different roots or feeders, may be connected when they are close together, thus making a network of the whole district, the proportions of conductors remaining the same as when not connected. This is a distinction from the network proposed by Mr. Edison, and a distinction necessary for economy. In this case there is more difficulty in managing the potentials, but it has this advantage, that if an accident happens to one feeder main, its fed district will, in some cases, be not quite in the dark. Considering the comparatively small chance of accident to feeders, as shown by our experience of gas, I would waive this, and in some cases I might even prefer that each block should be supplied from its distributing box by independent wires to each lamp. The potentials of all lamps are then absolutely constant, and, as shown before, there is less waste of energy in the distant lamps.

At Paddington, Mr. Gordon uses a modification of the independent wire system by leading a group of wires for a main, and cutting out more or less of them automatically, or by signals from the engine-house, according to the proportionate consumption in different parts. This is one example of many devices which the engineer may resort to in special cases, but which are not satisfactory as a general system.

The different potentials may be given to the mains in a variety of ways. Edison puts resistances in the feeders. Gordon does the same by cutting out some conductors of the main feeders. I prefer, after getting 100 volts, to add to the pressure by a number of dynamos of large quantity and only two volts pressure. Terminals come to studs, along which feeder contacts slide till the right pressure is attained.

I have not time in three lectures to go into

all these details. I must stick to the main questions.

Network Mains.

I now come to the network system, and after the care we have bestowed upon the multiple arc system generally, there is not much to say. In the form proposed and carried out by Mr. Edison, it is not economical, and I shall show you why. He leads his conductors along the face of each block of buildings, and wherever the conductors intersect, the + and — conductors are connected together respectively. Distributing centres are provided with feeders supplying them, and with wires to the engine-house to indicate the potential. Resistances are introduced into the feeder circuits to equalise the potentials. This is a beautiful idea carried out without calculation, and consequently not economical. It is verbally identical with what I have called the tree system, with the branches of separately fed districts connected. The chief practical difference is that Mr. Edison lays his conductors of the same size for a long way. In the tree system the economical size of conductor is chosen in every part. Secondly, Mr. Edison equalises potential by resistances in the mains which is hostile to economy. The importance of having a large number of feeding boxes and feeders is very great, for two reasons :—(1.) Repairs are more easily executed with less interference to many people. (2.) The equalisation of potentials may be made practically perfect.

The advantages of independent wires from lamps to distributing boxes are enormously increased by the fact that repairs do not affect other lamps. The only consideration to weigh against its advantages is the extra cost of thin insulated wires. This is a matter which it is impossible to touch in a general statement of the problem, but which the engineer must calculate for every special case before finally deciding.

The only advantage of connecting separately-fed districts is the prevention of darkness in case of accident to a feeder. I prefer to guard against this by splitting each feeder into two. It would rarely happen that both were damaged together, if laid separately.

Notice, in all systems of laying mains, the size of conductors in different parts is proportionate to what it would be if a wire came from each lamp by the shortest route.

On the wall is a diagram to show you the arrangement proposed by Mr. Edison, where you see separate dynamos connected with separate feeders, going to separate distributing boxes, which are connected to the whole network system.

My object in these lectures is to lay methods before you, not to give opinions, but it may be right that I should state to you my belief that the most satisfactory multiple arc system proposed is as follows :—1. As large number of distributing boxes as follows (the number depending on the type of dynamo, or *vice versa*). 2. Each box fed by a different feeder. 3. Each distributing box must be nearer to the central station than any lamp fed from it. 4. Small groups of lamps to be fed from the distributing box by separate wires. 5. The relative section of conductor at every point of a street to be the same as if every lamp had a separate wire going by the shortest street route to the central station.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

GROUP II.—MINING AND METALLURGY.

By C. Le Neve Foster, D.Sc.

This group has been divided into five classes :—

Class 8.—Machinery and Appliances used in Mines and Quarries.

The exhibits in this class are so numerous that it is necessary to group them under various headings.

1. *Prospecting by Boring.*—The chief feature of this department is naturally the diamond drill. Those who visited the Paris Exhibition of 1867, may recollect the perforator of MM. de la Roche-Tolay and Perret, which bored small holes for blasting with a rotating cutter armed with diamonds. Colonel Beaumont subsequently applied a similar bit to boring deep prospecting holes, which had hitherto been drilled by percussive tools, and with such success that of late years the diamond drill has, to a great extent, supplanted the other method of boring. The Aqueous Works and Diamond Rock-boring Company, Limited (176), show a complete prospecting drill on a carriage for boring small holes $2\frac{1}{4}$ inches in diameter; while Messrs. Thomas Docwra and Son (137) have erected the necessary plant for making larger bore-holes, with all the latest improvements; among these we may mention the moving crosshead, which can be swung round so as to leave the top of the bore-hole quite free, and a new method of setting the black diamonds in the large crowns.

The stones are fixed in tapered steel plugs, which slip into holes in the crown; the plugs can easily be extracted by a drift, and used for a crown of another size. One of the cores exhibited by Messrs. Docwra is from a bore-hole 24 inches in diameter.

In connection with the diamond drill, we must notice the novel and ingenious instrument called the clinograph (202), invented by Mr. E. F. Macgeorge. It has been generally assumed that, in spite of passing through rocks of varying hardness, the path of a hole bored by the diamond drill is quite straight. Actual experience reveals a very different state of things, and the deviations are so great as sometimes to render a bore-hole misleading and worse than useless, unless the deviations can be ascertained correctly. Mr. Macgeorge's plan consists in lowering into the bore-hole clear glass phials full of gelatine, each being fitted at the top with a bulb containing a plummet, and at the bottom with a bulb containing a small magnet. When the gelatine is heated, the plummet and magnet can move freely. Several of these phials, with the gelatine fully liquefied, are arranged along the axis of a brass cylinder, which is lowered into the bore-hole, and left till the gelatine has congealed. The direction and dip of the bore-hole are thus registered automatically; and when the phials are drawn up to the surface, it is simply necessary to place one of them so that the little plummet hangs vertically, and the little magnet points to the north, in order to know the precise dip and bearing of the hole. Mr. Macgeorge has a convenient clinometer for measuring the two angles. By repeating the observations at intervals of every 100 feet, the path of a hole can be mapped with accuracy. Judging from well-recorded instances of bore-holes, it is not too much to say that Macgeorge's clinograph ought to be regarded as an indispensable adjunct to a prospecting drill, especially in the case of a small hole bored in hard rock.

2. *Breaking Ground.*—(*a*) *Hand Tools.*—Improvements in the manufacture of miners' picks are by no means unimportant, when we come to consider how often in the day this tool has to be wielded. The Hardy Patent Pick Co., Limited (128) exhibit picks of solid cast steel with interchangeable handles, which have found favour in collieries and in metal mines. The Elliott's Patent Mining Pick Co., Limited (189), have the same aim in view, and their handle can be used for an axe, adze, or shovel, as well as for a pick. Macdermott's patent rock and coal perforator, brought forward by Messrs. Glover and Hobson (167), is a twisted auger worked by a rachet handle, for use in coal, shale, and slate; the same exhibitors have a percussive rock perforator worked by hand-labour, but machines of this class have not yet met with general approval.

The hand-drill of Messrs. Asquith and Ornsby (203) is worked by an endless chain, which enables a hole to be bored very close to the roof.

b. Machine Drills.—The use of perforators driven by compressed air for boring holes in hard rocks is one of the greatest improvements effected in mining of late years. No less than six machines are shown, known respectively as the "Adelaide," "Barrow," "Cornish," "Eclipse," and "Foster" drills.

The "Adelaide" drill (141) has no valves, and thereby resembles Darlington's perforator, which probably furnished suggestions to Mr. Wynne, the inventor of the drill exhibited. It is a compact and strong machine, and is doing good work.

The Barrow drill (201) can claim the merit, and no small one, of having been the first to overcome the prejudice of Cornishmen against machines of this class. Both the advance forward of the machine and the rotation of the drill are effected by hand, and the machine is reduced to a very simple form. It is a drill which is well liked at home and abroad. The Cranston drill (151) is another perforator of simple construction, the slide valve for producing the reciprocating motion is worked by a tappet on the piston; the advance and rotation are like those of the Barrow machine. The Cornish drill of Messrs. Holman Brothers (194) also has its valve worked by a tappet on the piston; the twist of the drill is automatic, but it is fed forwards by hand. The cradle is made in two parts, and when the groove in which the drill-slide works gets too large from wear, a thin plate can be taken out, and the groove is rendered small enough to fit the slide again. The Cornish drill is strong, and constructed so as to suffer little from rough handling by miners. Messrs. Hathorn and Co. (175) lay a good deal of stress upon the valve in their "Eclipse" drill, and upon the automatic advance. As a matter of fact, this automatic arrangement is frequently discarded in practice, and the workman regulates the feed by hand. The small "Eclipse" drill is light, and is easily moved about underground. The same exhibitors show an air-compressor, and an improved hydraulic pillar, or column, for supporting perforators. The carriage and four drills of Messrs. Foster and Sons (164) are such as have been used with success in Cornwall, Flintshire, and other places.

The absence of foreign drills, and especially of the Brandt rotatory drill, is to be regretted.

Messrs. Beaumont, Jones and Co's photographs (105) illustrate a return of the diamond drill to its original purpose of boring holes for blasting; but in this case, the machines are placed upon pontoons, and the holes are bored in sunken rocks which impede navigation. This application of the diamond drill has proved to be very valuable.

c. Explosives.—The ordinary explosives used for blasting have all been placed in Group XXV., and, therefore, this is not the place for expatiating upon the services rendered to mining by dynamite, blasting gelatine, and various forms of gun-cotton; there can be no doubt, however, that much of the success of machine drills is due to the strong explosives which are now available.

That blasting has been the cause of many explosions of fire-damp is now-a-days generally admitted,

and the ingenuity of inventors is being exercised to find a remedy for the danger. Some try to get rid of the flame of powder by a water cartridge inserted upon it; whilst Mr. Clark (193), with the same object, surrounds the explosive by a compound containing carbonate of soda and other chemicals. Compressd lime cartridges (177) have in some kinds of coal proved an efficient, and of course safe, substitute for gunpowder, and mechanical appliances may also be used. Messrs. Asquith, Ornsby, and Nicholson (192), have an apparatus reminding one of the plug and feathers, save that the two parts corresponding to the feathers are forced open by two wedges drawn together by a right and left-hand screw, instead of by one wedge driven in by a sledge.

Messrs. Bickford, Smith and Co. (195), in addition to their ordinary fuses suitable for all sorts of purposes, show a new instantaneous fuse and igniter, the object of which is to fire several holes simultaneously, a matter of importance in blasting out a large central core, when driving a level or sinking a shaft. Hitherto this has been done by electricity, but the new fuse enables the miner to attain his purpose without such aid. The igniter is a tin cylinder, from which proceed, like the arms of an octopus, small lengths of a special kind of fuse which burns instantaneously. One of these is inserted into each hole, and a piece of ordinary fuse serves to convey fire to the igniter. After lighting the ordinary fuse, the miners have plenty of time to retire, and when the fire reaches the igniter it flashes down in an instant to each of the separate charges, and they explode simultaneously, doing more work than if they had been exploded singly. If this fuse were sold cheaply I believe it would come largely into use. The British and Foreign Safety Fuse Company (196) exhibit various kinds of well-made safety fuse.

Mr. Stephen Humble (165) has produced an ingenious blasting plug to take the place of tamping or stemming. It is a hollow cylinder of thick india-rubber, which is placed in the bore-hole after the powder, and swells out when a conical brass plug is screwed into it. As the process of tamping is the most dangerous operation in blasting, any attempts to avert the risk overhanging the miner must be welcomed; but it is a question to be decided by practice whether such plugs will last long enough to make them economically available. Furthermore, the plug cannot give such a tight tamping as is usual, because the cone which squeezes out the india-rubber is drawn away from the powder, and because there is a little room for the escape of gases round the fuse. Time will be lost by the miner in looking for the plug after a blast, but, on the other hand, no time will be taken up in preparing stuff for tamping, and the operation of stemming will be shortened.

3. *Methods of Securing Excavations.*—Although the securing of underground excavations forms an important and often costly part of mining, there are no exhibits to illustrate any of the new methods of using iron instead of timber.

Processes for preserving timber from dry-rot have scarcely received that attention from miners which they deserve, but in Group II. there are no exhibits. In Group VII., Messrs. Gardner and Son (963) show a pit prop treated by their patent process, which, though somewhat expensive, appears to be useful.

4. *Underground Haulage and Hoisting Machinery.*—M. Legrand, of Mons, has a good show of plant for portable railways, amongst which his iron sleepers for mines may be specially noted. His arrangement, called automatic wedging, is a simple and effective method of laying down rails which may require to be shifted frequently.

The Ukside Engineering and Rivet Company, Limited (159), exhibit a strong and compact hauling engine for use underground, with steam or compressed air. Messrs. Robey and Co.'s (166) semi-portable engines for winding purposes have borne the test of many years' practical use in all parts of the world. The engine exhibited is mounted on their patent wrought-iron tank foundations, an arrangement which, in some instances, forms a useful improvement upon the older form.

Where water-power is available, Messrs. Bailey's water-motor (208) is a convenient machine, not only for winding, but also for many other mining purposes.

The greatest novelty connected with winding is the new kind of wire rope, invented by Mr. Latch (178). He employs wire specially drawn, of various sections, such as crescent-shaped wire, V-shaped wire; these wires will fit together closely, and form a rope with a smooth cylindrical surface, without any interstices. Mr. Latch's ropes have several advantages over the old form, among which is a smaller diameter for a given strength. According to the inventor, his locked-wire rope, 3 inches in circumference, weighing $13\frac{1}{2}$ lbs. per fathom, equals in strength the old style of rope 4 inches in circumference, weighing $18\frac{1}{2}$ lbs. per fathom. If actual practice confirms Mr. Latch's statement that it is possible to make a reduction of 27 per cent. in the weight of the rope, and at the same time to gain other advantages, such as complete protection of the inner coils from wear, perfect roundness, and increased flexibility, the value of the new mode of manufacture will be readily admitted by mine owners.

Persons who have once witnessed the rapidity with which mineral is extracted from mines by cages, are painfully impressed by the slow processes still in use in Cornwall, and many other metalliferous districts. Any improvement capable of being applied to existing plant deserves commendation. By an ingenious arrangement, which could not be understood without a figure, Messrs. Kitto, Paul, and Nancarrow (188) make the iron box, or skip, turn over automatically, and discharge its contents on reaching the top of the shaft. When the rope is lowered, the skip at once rights itself, and descends properly. The services of the lander can be dispensed with, and the winding can proceed much more rapidly, for there is no delay at the surface. As the new style of skip will work

in perpendicular, inclined, or even crooked shafts, and does not necessitate any alteration in the ordinary guides, it is likely to meet with a favourable reception among those metal miners who are still unable to fit their shafts with the best hoisting gear. It may be remarked that this skip is not an untried invention, it has been in use for some time at Frongoch mine, near Aberystwith.

Among the safety appliances to prevent accidents in the case of overwinding, or if the winding rope breaks, we may call attention to Mr. Stephen Humble's (165) detaching hook. He has now added an improvement which prevents delay in getting to work after an overwind. He also shows safety catches for wooden and for wire-rope guides.

5. *Drainage.*—The direct-acting pumping-engines of Messrs. Hayward, Tyler, and Co. (168), largely used at collieries, have been transferred to Group XI., which contains the exhibits of other well known firms, such as Messrs. Hathorn, Davey, and Co., Messrs. Tangye Brothers, and the Pulsometer Engineering Co., Limited.

6. *Ventilation and Lighting.*—A few fans are shown, but the ingenuity of inventors seems to have been expended principally upon improvements in the safety-lamp.

If Mr. Evan Evans's lamp (103) is placed in an explosive atmosphere, the gauze becomes filled with flame, which burns through a fine cord. This releases a shield which shuts the lamp entirely off from the surrounding atmosphere, and it goes out before it can lead to an explosion. Marsaut's well-known lamp is shown by Messrs. Davis (107), and Messrs. Mills (112). The latter have applied Ryder's patent lock to the Marsaut lamp, which enables the shield and the bottom of the lamp to be securely locked with a single lead bolt.

William Purdy's comparatively simple lamp (108), with a strong brass shield, will resist explosive currents of very high velocity, and gives a good light. To prevent men from opening the lamp at improper times, Mr. Purdy has devised an ingenious pneumatic lock which requires the aid of an air-pump to withdraw the bolt.

Morgan's lamp (118), in addition to the wire gauze, has various envelopes of thin sheet metal, which leave tortuous passages for the air; it resists the highest velocities of explosive currents, but it has the disadvantage of being heavier than the ordinary safety-lamp now in use.

The Wolf lamp shown by Messrs. Schäffer and Budenberg burns benzine, and gives a good light; it is coming largely into use in Germany. The lock is a bolt kept in its place by a spring, and the top cannot unscrewed until the lamp is brought against a very very powerful magnet. The lamp can be fitted with a simple arrangement for re-lighting it underground without removing the gauze.

Two electric safety lamps deserve special notice. Mr. J. Wilson Swan has succeeded in producing a small portable incandescent lamp which, with its secondary battery, weighs only 6¼ lbs., and the cylindrical case containing the cells is only 4 inches in diameter by 8 inches high. It will give the light of half a standard candle for twelve hours, or the light of ¾ of a standard candle for 8 hours. The bulb containing the carbon filament is lightly held by an elastic clip, and it is almost certain, that any blow strong enough to smash the outer glass and inner bulb would knock the latter out of its place, and so break contact before fracturing it. Mr. Swan estimates that the cost of renewing the electric lamps and recharging the batteries will not exceed the amount now paid for oil and for cleansing and repairing Davy lamps.

M. Trouvé's incandescent lamp (1,361) receives its current from a primary battery. The bulb with the incandescent filament is protected by an outer glass and wire cage. The lamp and battery weigh about 6½ lbs., and will give a light of four to five candles for two to three hours; or, as the light can be graduated at pleasure, of one candle for twelve hours. The total height of the lamp and battery, including handle, is eleven inches, and the outer diameter of the cylindrical ebonite case is five inches. The price of the lamp is 50 francs, and the cost of maintenance is estimated at 6 centimes per hour. M. Trouvé has also constructed a smaller lamp weighing 2¾ lbs., which gives the light of two candles for two or three hours.

Three fire damp indicators are exhibited. Mr. Garforth (110), by means of a flexible india-rubber ball, takes a sample of air from a hole in the roof, or from workings which cannot safely be entered by a lamp, and then squeezing the sample on to the flame of an ordinary safety lamp, observes the effect in the usual way. Mr. Liveing's indicator (123) depends upon the difference of brilliancy with which a platinum wire glows during the passage of an electric current, according as it is surrounded by pure air, or an atmosphere containing fire damp. As it gets out of order easily, and is very expensive, it is not likely to come into general use. The acoustic indicator of Mr. Blaikley (113) is interesting scientifically, but is not of practical importance. The difference between the note of pure air passing through a reed and that of air mixed with fire damp is marked, and, with attention, the indicator is said to show less than 2 per cent. of fire damp.

The Pieler indicator, a Davy lamp burning alcohol, which furnishes a flame very sensitive to fire-damp, has unfortunately not been exhibited.

The Fleuss breathing apparatus (101), for enabling persons to enter coal mines after explosions, is an invention of great merit, but we doubt whether it is kept in readiness at many collieries.

7. *Dressing of Minerals and Coal-washing.*—Since the expiration of the original patent of the Blake crusher, various makers have made jaw-breakers of this class; but in designing improvements their aim seems to be to satisfy the requirements of contractors for road metal rather than those of miners. Great stress is laid upon "cubing jaws,"

and mechanical arrangements which will give the stone a sharp and sudden crack.

Mr. Marsden (1129), the original maker of the Blake machines in England, has a new form of breaker, said to give an improved yield of road metal and less waste in chips and dust, and Mr. Baxter (144) claims the same advantage for his stone-breaker, with its more complicated "knapping motion." Hall's stone-breaker is like Blake's, but has two jaws placed side by side which act alternately; as all the parts are balanced, less power is said to be required to drive it.

For pulverising to finer sizes, there is an important crusher invented by Mr. Marsden (1129). It resembles his stone-breaker by having two jaws, one fixed and the other movable, but the moving jaw has a rubbing as well as a squeezing action. As the wearing parts are simply two plain jaw-plates, which can be replaced with ease, the machine is likely to come largely into use. Among the pulverizers we may also mention Lucop's (146), consisting of two cylinders, which are thrown outwards by centrifugal force, and crush the ore against a circumferential steel band. Messrs. Morris and Wood (145) show edge-runners, resting upon a revolving bed, for grinding phosphates, cement, &c. The crusher of MM. Bertet and Sisteron (139) is novel. The reduction to powder is effected by a truncated cone travelling backwards and forwards upon the surface of a revolving cylinder.

Husband's oscillating cylinder stamper (149) is an improved form of his pneumatic stamps, and the record of practical working proves it to be a valuable invention.

A drawing of a coal washer, on the principle of an ore jigger, is exhibited by Messrs. Hall (148), and a model of a somewhat similar machine by Messrs. Sheppard (174).

A continuous plunger jig and an American Frue vanner form part of the large exhibit of Messrs. T. B. Jordan, Son, and Commans (141). Messrs. Scott and Co. (173) have a magnetic separator worked by a dynamo. Though designed originally for extracting iron from refuse containing brass and iron, it may be usefully applied to ore concentration when one component of an ore is, or can be rendered, magnetic. In this machine electro-magnets on a revolving disc alternately acquire and lose their magnetism by means of a commutator, and pick up the particles of iron lying on one travelling belt and drop them on to another.

While on the subject of dressing, we may refer to the exhibit of the Mudford Fuller's Earth Works, Limited (206). This company mines a five-foot bed of fuller's earth near Bath, and the novelty now introduced consists in crushing and washing lumps of impure fuller's earth, which were formerly thrown away as valueless. The lumps are crushed by edge-runners, and the product is washed by a stream of water into settlers, which catch the coarse stone and sand, while the finer particles pass on into a depositing tank. The deposit is dug out and dried in kilns like china clay. The merit of the company consists in the application of known processes to a new material.

Class 9.—Production and Manufacture of Iron and Steel.

The importance of this class must be estimated by the quality, and not by the quantity, of the exhibits. Sir Henry Bessemer shows early samples of his steel, which have great interest in the history of his memorable invention. Messrs. Thomas and Gilchrist (156) have a large series of samples from British and foreign works, to explain the basic process as carried out in Bessemer converters or Siemens' furnaces, and Mr. Snelus (136) supplies illustrations of numerous improvements in the manufacture of steel. The Casson-Bicheroux gas generators (119) are easily and cheaply applied to existing furnaces, and have given much satisfaction. The Batho furnace is an improved form of furnace for the open hearth process. It is stated that the newer form costs less for repairs than the Siemens furnace, as all the parts are easily accessible, and requires less fuel. That the ingenuity and inventive genius of Mr. Nordenfelt (2,640) are not confined to guns, will be seen by an inspection of his so-called Mitis wrought-iron castings. Mr. Nordenfelt melts wrought-iron scrap in close pots, in special furnaces heated with petroleum residue, and he obtains the iron in such a liquid state that he can run it into moulds, and produce very fine castings. These castings are intended to replace forgings; they are strong, tough, and soft; they will weld, and can be bent without fracture quite as well as forgings; they require no annealing. When we consider the saving in price effected by having a casting instead of a forging, it is evident that there will be no lack of work for Mr. Nordenfelt's process. The Bower-Barff process (198) for producing a coating of magnetic oxide upon articles made of iron or steel, and so preserving them from rust, though now pretty well known, does not appear to have met with that success in this country which it deserves.

Class 10.—Forging and Foundry Work.

Stewart's cupola (1,187) is said to melt one ton of iron with one hundredweight of coke. It is provided with a separate close receiver, into which the charge runs and collects, and from whence it can be tapped at pleasure.

Class 11.—Metallurgy of Metals other than Iron, with the exception of the Precious Metals. Alloys.

Here, again, the exhibits are few, and do not represent the process in metallurgy of the last quarter of a century. There are good shows, however, of new copper alloys that are coming into use, viz., phosphor bronze (162), delta metal (161), and manganese bronze (163). The solid drawn copper tubes of Muntz's Metal Co., Limited (200), and their coils,

made by a new and very simple process, deserve much praise.

Class 12.—Metallurgy of the Precious Metals—Gold, Silver, Platinum.

The excellent model lent by the Deputy Master of the Royal Mint shows very clearly Mr. F. B. Miller's process for refining gold by chlorine gas. To grasp the full importance of this process, we must recollect that "in the Australian mints alone gold to the value of four millions sterling is annually refined by its aid."

Barker's method of keeping amalgamated plates bright can be seen at the stand of the Electro-Amalgamator Company, Limited (154). A positive current, generated by a small dynamo, is made to pass from a carbon rod through the water to the amalgamated plate, which is thus kept bright and free from tarnish, and is always fit for catching gold. Though the process has been before the public for some time, it does not appear at present to have taken root in gold mining districts.

In the Cassel process (153), electricity is called in to assist the metallurgist in another way. A current from a dynamo is made to pass through the finely pulverised ore and salt water revolving in a drum. Chlorine is liberated, and, attacking the gold, converts it into the soluble terchloride; this passes through an asbestos cloth filter, and, on reaching the negative pole, the solution is decomposed and the gold deposited in the form of a black powder. The addition of lime prevents iron and other metals from passing into solution. This ingenious invention cannot be said to have gone beyond the experimental stage, and it remains for actual practice, on a large scale, to decide how far it will prove capable of treating refractory gold ores with profit.

Messrs. Huntington and Koch's gold amalgamator (172) is an apparatus by which the pulp from the stamps may be readily passed through a column of quicksilver a foot or more in height; practical trials in Australia have given good results. The same inventors propose to extract silver from ores by passing them, after roasting, through red-hot molten lead, by means of an apparatus similar to the gold amalgamator.

Though scarcely a metallurgical process, the operation of gold-beating has been placed in this class, and the stand of Messrs. Thomas Bennett and Son (134) has certainly proved a great attraction to visitors. Their improvement consists in employing a water bath for drying the packets of skins, or moulds, in which gold is beaten. Formerly, the moulds were placed between two hot iron plates to dry them, and unless great care was exercised, the skins were too dry or too moist, and much leaf was spoilt owing to the unevenness of the dried-up skins, or the adhesiveness of the moist ones. The simple expedient of a water bath has overcome a difficulty which had troubled gold-beaters for many centuries.

The general progress of mining and metallurgy during the last quarter of a century has been so well set forth by Mr. Bauerman, in his introduction to the Official Catalogue for Group II., that it is quite unnecessary for me to enter upon this subject. I will only call attention, in conclusion, to the tendency to press electricity into the service of the miner and the smelter. The miner already uses it for firing shots, illumination, transmission of power, underground railways, signalling, speaking by the telephone, extraction of magnetic minerals; whilst the metallurgist finds it of value in assaying, in the electrolytic separation of metals, and, lastly, in precipitating the fume from furnaces. It is true that very many of these uses are only in the infantile stage, but the end of this century will probably witness a much more wide-spread application of electricity in mining and metallurgy.

The number of visitors to the Exhibition for the week ending Tuesday, 6th October, was 120,781. Total since the opening, 3,137,935.

H.R.H. the Prince of Wales has appointed Monday, 9th November, for the official closing of the Exhibition.

MUSICAL PITCH.

At a public meeting convened by the Royal Academy of Music on 20th June last (see *ante* p. 868), a resolution was passed to the effect "that steps be at once taken for securing the adoption of the standard pitch in the principal orchestras, and also, if practicable, by the regimental and other bands of the British Army." In accordance with this resolution, steps were taken which are explained in the following letter from Sir George Macfarren, published in *The Times* of Saturday, 3rd instant:—

Sir,—The following particulars, and, very far more, their result, are so important to all musicians in England, and to every one who visits this country from abroad, that I trust you will give them publicity in *The Times*.

On the receipt of a communication from the Foreign-office, which comprised a letter from Her Majesty's Minister at Brussels, quoting the decree of the King of the Belgians to the effect that all military bands, musical schools, theatres, and other institutions subsidised by the Government throughout Belgium, should adopt what is known as the "French Normal Diapason" as the standard of musical pitch, the Directors of the Royal Academy of Music convened a public meeting, which was held at St. James's-hall on the 20th June last, to consider the subject. Several resolutions were then passed as to the desirability of establishing some pitch which should be uniform in all Great Britain, and also in conformity with whatever may be most likely of general acceptance elsewhere, the object being to avert, if possible, the serious inconvenience to vocalists, instrumentalists, and

manufacturers that has been consequent on the diversity which has prevailed here during recent years. A committee to carry these resolutions into effect was then elected, consisting of eminent men of science, musicians, and musical instrument makers. The first step of this committee was to send a memorial to the Commander-in-Chief, requesting that the bands of the British Army might be required to have their instruments tuned to the proposed pitch, because, as the players on wind instruments in the orchestras of concert-rooms and theatres are, for the most part, drawn from military bands, the pitch of their instruments, which is almost inflexible, necessarily regulates that of all others, and singers are equally compelled to its adoption. The following is a reply to the letter of the committee :—

"Horse Guards, War-office, S.W., August 5th, 1885.

"Sir,—With reference to your letters of the 6th and 18th ult., in which the Directors of the Royal Academy of Music request the report of the Field-Marshal Commanding-in-Chief in bringing about the adoption of a standard musical pitch for the United Kingdom, I am directed to acquaint you that, owing to financial and other difficulties which are too great to be overcome, his Royal Highness is unable to support the adoption of the standard musical pitch, as proposed.

"A. Alison, A.G.

"John Gill, Esq., Hon. Sec."

On the perusal of the above, the committee came, after serious consideration, to the following resolution :—

"That, although the establishment of a musical pitch for England which would accord with what is likely to prevail generally in other countries be most desirable for the interests of native and foreign art and artists, the impossibility of controlling the musical arrangements of Her Majesty's forces renders such an establishment totally impracticable, and this committee does, therefore, dissolve itself, as being disabled from carrying into effect the measures confided to its care."

G. A. Macfarren, Chairman of the Committee on Musical Pitch.

Royal Academy of Music, Tenterden-street, Hanover-square, W., Oct. 1st.

Obituary.

The Earl of Shaftesbury, K.G. — Lord Shaftesbury, who died on Thursday, 1st inst., was elected a member of the Society of Arts in 1880. He was born on April 28th, 1801. His long philanthropic career has been fully described elsewhere, but it may be interesting here to mention more particularly his special connection with sanitary work. When he first entered Parliament for Woodstock, in 1826, house sanitation was a subject unthought of, and even the old Acts respecting public sanitation, the earliest of which was passed in the reign of Richard II., were neglected. The Public Health Act, out of which arose the General Board of Health, was passed in 1848, and from 1849 to 1854 Lord Shaftesbury acted as a Commissioner. In the recent (March, 1884) sittings of the Royal Commission on the housing of the working classes, the Earl, in reply to a question from the chairman relating to the "Act to encourage the establishment of Lodging-houses for the Labouring Classes,"* an Act passed as recently as in the year of the great Exhibition (1851), said, "At the time when that Act was passed there was no public feeling in the country on the matter at all, and, therefore, it passed unnoticed." Two Bills affecting the sanitation and construction of lodging-houses he had the accidentally unusual distinction of carrying through both Houses. The first was "The Common Lodging-houses Act," and the second, "The Labouring Classes Lodging-houses Act." As Lord Ashley he conducted them through the Commons, and succeeding to the earldom on his father's death at the time, he conducted them through the Upper House. But he was not content with legislation to direct what others ought to do or might do. He wished to lead the way, and hence connected himself with those who could form an association to erect the kind of buildings he had in his mind in framing his Bills. The association, which was of an experimental kind, had no "shareholders," that is, those who subscribed their money to the fund for the building of lodging-houses expected no dividends. The money that accrued from rent of blocks was not to be spent in dividends, but in erecting new blocks. Before the recent Royal Commission, in answer to a question from Mr. Godwin, Lord Shaftesbury definitely stated this (Minutes of Evidence, page 10, No. 130).

General Notes.

Albert-hall Choral Society.—The Albert-hall Choral Society, under Mr. Barnby's direction, announces ten concerts, the first of which will be given on Wednesday, November 4. The prospectus states that the attendance during last season was considerably in excess of that preceding it—a fact accounted for by the production of Wagner's "Parsifal" in a concert arrangement. The most prominent feature of the forthcoming season will be Gounod's new oratorio "Mors et Vita," two performances of which—on Wednesday evening, November 4, and Saturday morning, November 14—will be given. The same master's "Redemption," Berlioz's "Faust," Handel's "Judas Maccabæus," Sullivan's "Martyr of Antioch," and Hiller's "Song of Victory," are also in the programme. Mesdames Albani, Valleria, Anna Williams, Patey, Hilda Wilson, and Messrs. Lloyd, Maas, Santley, Barrington Foote, and Foli are among the vocalists engaged.

* Vic. 14-15, cap. xxxiv., 24th July, 1851.

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CANTOR LECTURES.

DISTRIBUTION OF ELECTRICITY.

By Prof. George Forbes.

Lecture III.—Delivered February 16, 1885.

In the last lecture, I was engaged in describing the different methods which have been used to apply what is called the multiple arc system of electric lighting. The multiple arc system is a system in which there are one positive and one negative lead between which the lamps are placed. I think that we succeeded in arriving at several very general conclusions which simplify the consideration of the manner of laying mains a great deal. I think I am right in saying that in the past the practice of designing mains has been to a certain extent haphazard; the mains have been selected a little at random, and then perhaps afterwards adjusted to a slight extent; but there has not been that thorough estimating of the effects which could be arrived at by calculation, and in consequence of that there have been some grievous failures in electric lighting on the multiple arc system. I think we arrived at one or two important generalisations which must be accepted as necessary for economy, and in such a system—the multiple arc system—the amount of copper used in our mains is so enormous that everyone must admit that economy is the first consideration, and that all such engineering difficulties as there may be must be met by the engineer as difficulties which can be conquered. The most important results which we arrived at were, I think, pretty clearly shown by illustration by the diagram of the city of Chicago, as we chose to call it (see *ante*, p. 1048), in which it was shown that, in order to have good distribution, there must be no great variation of pressure in the mains, electric pressure in the mains corresponding, as you will remember, exactly with hydraulic pressure if it were a service of water; and in order to prevent our having too great a variation of pressure in different parts of the district, or in the same district at different periods of the night, when the consumption over the district varies, it is necessary, as I showed by means of the diagram, to have a large number of distributing boxes with mains, trunk lines of conductors coming to these distributing boxes and feeding them, and each one of these distributing boxes then serving to light up a certain space, which in the diagram is essentially a triangular space. And I also gave you the rules for determining what is the size of the district which may be lighted up by such a distributing box, and I think everyone here will agree with me that the limit was very confined indeed, compared with the general ideas which have prevailed as to the number of distributing boxes which are required; that is to say, that upon the assumption upon which we have been working of the size of conductor required to carry a certain current, we concluded it would be necessary to have the distributing boxes so close that no lamp should be at a greater distance than 124 yards from the distributing box. Another important point which has been, I think I may safely say, altogether neglected in all schemes which have been hitherto issued for distribution of electricity from central stations is this, that the distributing box, the point from which the distribution takes place, must be closer to the central station than any of the lamps which are fed by that distributing box. As a general rule, the distributing box has been put in the centre of the district which it feeds, and that is a mistake; it ought to be nearer the central station than any of the lamps which it feeds. I gave you also in the last lecture some account of the relative cost of different systems of lighting in the multiple arc way, and it was found that by introducing a large number of distributing boxes in this way the cost was very materially reduced; but, at the same time, the cost was very great, even with these distributing boxes. And the cost may be divided into two parts; first, the cost of the supply wires, the conductors which are sup-

plying the electricity from each distributing box to the houses, which are represented by the square lines round each block of buildings (Fig. p. 1048); and secondly, there is the expense of the feeders, the conductors going up to the distributing boxes. Now when we increase the size of our district to any considerable extent, the cost of these feeders, these trunks which carry the electricity to the distributing boxes, is far greater than the cost of the supply system of conductors. If there be a means of reducing the cost in this way, that is to say, any way of cutting out these feeding conductors, that will be a very great economy indeed.

This evening I will leave altogether apart the system of multiple arc lighting, which is the system which has been almost universally adopted in the past, and I shall speak this evening about the different systems which have been proposed and carried into effect for using higher pressure in the mains. The work which is done by a certain number of lamps is a perfectly definite amount of work, and it is measured by the product of the pressure of the electricity into the quantity of the electricity which flows. If we increase the pressure, we diminish the quantity of electricity that flows; that is to say, we diminish the current, and if we diminish the current, we can diminish the size of our conductors.

Now a great deal has been talked about the danger of introducing high pressures in electric distribution. I think that I shall find general agreement among competent people when I say that a great deal of what has been talked in this way is pure nonsense, and that high pressures are not in the least more dangerous than our present systems of illumination; that if we have to bring high pressures of electricity through a district, those pressures are confined to the wires, and it is only in the case where there is disgraceful negligence of duty, and a disgraceful leakage towards the earth in some part of the system, that it is possible for anybody to receive a dangerous shock from the wires of such a system. The wires which conduct the electricity into a house of any of these high potential schemes can never have a greater difference of pressure between them than what is required for the lamp; that is, in the present state of affairs, something like 100 volts. We will say that is the highest pressure there can exist between the two wires, and it seems almost incredible that there should ever be allowed to be a leak in the system so great that when a person touches one of the wires he should have a high current flowing through his person which would be dangerous. If we are to abolish the idea of using high potentials simply because of this vague notion that some time a shock might be experienced, we might as well abolish the whole system of gas lighting because it is possible that people can go into rooms where there is a leakage of gas with a lighted candle. The danger from gas is infinitely greater than that which can ever come from high potential electricity, and the difficulty of detecting a leakage of gas is likewise infinitely greater than the difficulty of detecting a leakage of electricity. A properly organised system of distribution of electricity at high potential would render a severe shock to any person absolutely impossible, and that is the point which needs to be dealt on very strongly at present, because so much has been talked—and so much nonsense has been talked—about the dangers of high potentials.

I have often found a great convenience in describing the effects of electricity and the systems of distribution by reverting to the analogy of water pressure, and, I think, those of you here who are not deeply conversant with the subject of electrical engineering will perhaps be assisted by a few words of reference to the analogy of water pressures. At present we see through different parts of London pipes being laid for supplying power by means of water at high pressure. This water is utilised in motors or turbines, through which the water passes. The water pressure is remarkably analogous to the pressure of the electricity in our mains; the turbines or other motors which are used to develop the power have remarkable analogy to the incandescent lamps or the arc lamps, or the electric motors which may be used with a system of distribution. Now, in the manner of laying pipes for water-power which we have all observed in the streets in London, all these turbines or water engines are connected directly on to the same set of pipes; in other words, they are all connected in multiple arc, as we would say in electric language. But it would be quite possible to conceive of two turbines connected together in series; that is to say, with a very high pressure in the mains first driving through one of these turbines, and then the outflow of water from that turbine still admitting of considerable high pressure to a second turbine, which it would work with the superabundant pressure which would exist. This is exactly analogous also to the electric system of distribution in

series; and this will be clear by examination of the diagram (Fig. 1), where this circle represents the dynamo machine with the two leads coming from it, and here are a number of circuits, each circuit having two lamps in series. This is exactly equivalent to a main to come along here, split into a number of

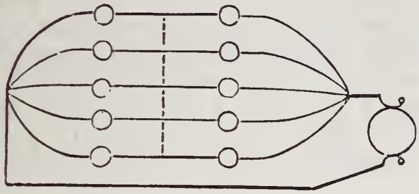


Fig. 1.—Multiple Series.

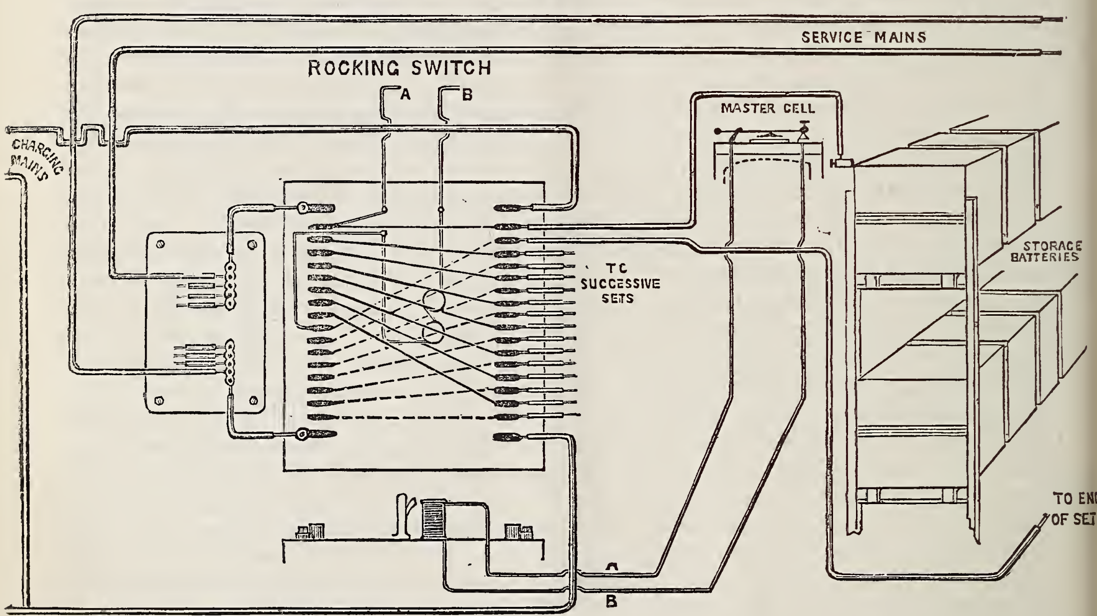
water pipes, with two turbines put in series. It follows that the pressure of water required to drive these two turbines is double the pressure required to drive the one. So it is exactly the same in electric distribution. We simply have to increase the pressure when we put a large number of lamps in series.

Now, there are several different ways in which high potentials can be used effectively and with economy. I will begin with mentioning the probable future which there may be in the application of secondary batteries. We often hear it remarked that the present systems of electric distribution are weak in some points, and that if only a system of secondary batteries were introduced, everything would be clear; and there is no doubt that by introducing secondary batteries a great deal of facility is given to the scheme. In the first place you can have a much smaller engine power, much smaller dynamo power, because your dynamos can be working the whole day charging these accumulators, and only used for supply when it is required. In the second place, you can put your secondary batteries all in series over a large district, and charge them all up in series, and then discharge them each to its local district, a small number at a time, and a small number at one place. In this way, by using high potentials, of course we should use small currents. In the hydraulic analogy, by using high pressures we require a smaller volume to flow, and therefore we should require smaller conductors, and, consequently, there would be a saving in laying down our copper. This is perfectly true, and there is not the slightest doubt a secondary battery system is of the utmost value, and would help us enormously. But at the present moment there are several difficulties in the way of introducing secondary batteries like this, and the first is perhaps the most fatal one, and that is that we have no secondary battery. I do not mean to say that much has not been done in the last four years in improving secondary batteries; but at the present time we have not sufficient confidence in the length of life and economy of secondary batteries to justify any engineer in depending upon them in designing a scheme of distribution. But I must say that there is a great probability of something being done in this direction, because there is such a vast amount of intellect in the whole world being devoted to this particular line, trying to perfect it, and already I have seen such enormous improvements in secondary batteries of late, that I cannot help thinking that very likely soon we shall arrive at something much more near perfection; and for this very reason I consider it is of the utmost importance that engineers should consider all such schemes which enable them to use high potentials, because, even though at the present time such a scheme as that introduced is imperfect to a certain extent, those schemes which lay down small wires for using with high potentials are the very schemes which will become applicable when the secondary battery is really a commercial thing in our possession; and, therefore, any person who has at the present moment to lay down a large system of lighting with the multiple arc system, would perhaps find, in the course of a year or two, that the whole of this enormous cost of copper he had laid down would be utterly wasted, because some discovery which had been made would enable him to use smaller conductors. For this reason I consider in designing a scheme of electrical distribution an engineer should consider the great importance of a probable discovery in the way of secondary batteries.

There has been one large experiment in the way of secondary batteries made at Colchester, and I have got diagrams here showing schemes of electrical distribution. With respect to the diagram at the other end of the room, which was referred to in the first lecture (Fig. p. 1037), I would simply say, if you have troughs, or good-sized channels in which your conductors are laid, there is very little difficulty about your insulation; with a good trench and plenty of room, the engineering difficulties are comparatively trivial, so long as you will remember the facts which I pointed out in my

first lecture, that you are not to trust to your insulating material as the support for the conductor. Your conductor must be supported by a substance capable of supporting it, not by a bituminous compound through which the conductor will sink in the course of years. But there are no engineering difficulties if you are able to have a dry trough for conducting your wires, and I am perfectly of opinion that if you have the mains laid down in that way you can use your 5,000 volts with perfect facility, and there will be no danger; and with proper tests regularly made, such a system would not only be possible, but perfectly safe. The diagram (Fig. 2) shows the arrangements which are made at Colchester by the South Eastern Brush Company for distributing their electricity. The dynamos with the charging mains act through what is called a rocking switch into the secondary batteries. Now in this supply system, first we have charging mains coming to the secondary batteries situated in different districts through the town, and then from the secondary batteries we have service mains going away to different houses which are to be supplied, and this rocking switch is controlled by what is called a master cell, which is simply a cell with a diaphragm, so that when the ebullition of gas becomes too great, the diaphragm is raised and the contact is

Fig. 2.

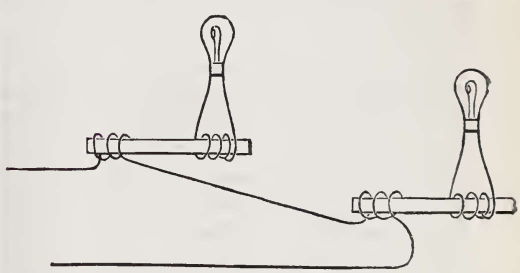


made, which switches over this rocking switch, and the cells then being considered to be thoroughly charged, are transferred from the charging system of mains to the service system of mains. That is the arrangement which was adopted there. One of these cells which are used there is shown here, one of the Consolidated Company's cells, which I have lately had the opportunity of testing very carefully, and which seem to give fair results; and I have upon the tables below two plates, a positive and a negative plate, and you can examine them and see how they are constructed. Let me put in a word here in parenthesis. I do hope that those who are electricians will not allow the term negative to be applied to what ought to be positive, and the term positive to what ought to be negative. I cannot understand why, since secondary batteries have been introduced, the whole language which electricians have been accustomed and got habituated to should be utterly reversed, and if certain companies who make these batteries persist in calling the plates in that way, I don't see why electricians should adopt them, and why they should not stick to the terms they

have been accustomed to use. I only hope a word said in season here and there will lead to electricians insisting on proper terms being given to these plates. Here also I have some plates well worthy of examination kindly lent me by the Electrical Power Storage Company. I may say that I had the good fortune to look through the work they have been doing of late, and I have been very much struck by the enormous progress they seem to have made in the practice of the construction of cells, and the maintenance of them in good order, and the prevention of the sulphating of these plates, which has been a source of very great trouble; and one of the chief things I was shown was the way in which these negative plates are kept in good condition, and how it is apparently impossible to injure them by overcharging. I believe I am right in pointing to this one [indicating a cell on the table] as one which has been persistently overcharged with the idea of trying to damage it, trying to make it worse, and if you look at it you will see as good a plate as you ever saw in your life in any secondary battery, the material perfectly sound and excellent. It really seems to show that one of the chief difficulties that has been met with is charging with too weak a current, and allowing the battery to degenerate, and not keeping it thoroughly charged up.

Next, I wish to draw your attention to a system of supply with high potentials which has been introduced by means of secondary induction currents. It is a very old idea to use induction currents in order to use a high potential current in the mains, and a low potential current in the supply service. I believe that the first patent which I have come across taken out in connection with this, was by Mr. Harrison, in the year 1857, and since then it has been patented over and over again, and here is a general idea of it shown in this diagram (Fig. 3), where there are supposed to be rods of iron surrounded by coils of the main wire; here is the main wire coiling around one end of these iron bars. The lamps, then, have their terminals connected by a wire which coils around the iron bar also, an alternate current is used to pass through these main coils, and it sets up alternate magnetisation in opposite directions by these iron bars, and the magnetisation induces electric currents in this wire which is connected with the lamp, and, consequently, we are able to magnetise this bar by the main wires with any potential that we please, and we are able to draw off, by these induced currents, a current of any potential that we please. In this way different lamps in different parts of the circuit can be fed with a current of whatever pressure you please, although the main exciting current is of very high pressure indeed; but, mark this, there is absolutely no danger in this system, because the charging current is in a closed circuit which never goes near the rooms where the lamps are actually at work; a lamp thus never has over the potential which is required for that lamp, and the high pressures which are used in the mains are confined simply to a closed circuit of wire; therefore there is absolutely no danger in such a system so far as the conduction of electricity to any person is concerned. I may say that, owing to the construction of such apparatus, it acts as a condenser, and so might give a severe shock. But this danger can be reduced to

FIG. 3.



limits of safety, and tested for safety by ordinary electrical methods. I have said that this is a very old system. The idea is very old; but it is only in the last few years that it has been worked out practically and with confidence, with a confidence that does honour to M. Gaulard, I may say, for the way in which he has attacked this problem; he was confident from the very first. I think it was three or four years ago when we first saw his apparatus in the Westminster Aquarium; since then he has been improving it, and has brought it to a practical issue. Since then I have not myself had the opportunity of experimenting upon the apparatus, but I simply draw my conclusions from the reports, in the first place, made by Dr. Hopkinson and others; and I have not the slightest doubt that from these secondary generators it is possible to get a return of 90 per cent. in the lamp circuits. This is a result which is very remarkable, and is worthy of far more

serious consideration than it has received up to the present time from most people, though of course many advanced electricians have been looking with eager interest at the result of these experiments. During the course of the last summer experiments were being made, as most of you are aware, at the Electrical Exhibition at Turin, and I have on the wall a plan of the scheme which was used there, and of the way in which the wires were used. Altogether the circuit had a length of about fifty miles; and we have evidence of the large number of different kinds of lamps used upon that circuit—a large number of Bernstein, Swan, Siemens, and Edison lamps, arc lamps and glow lamps—a large number of different lamps of different pressures, all worked from that central station over that great distance, so that the matter of distance is apparently overcome; these distances were of course much greater than they need be in any town distribution. I don't think I will say anything more about the system just now, except this, that if there is no difficulty about the expense, it is well worthy of far more attention than has been given to it up to the present. I had the pleasure of looking at the installation which is being commenced at the Grosvenor Gallery the other day, and I see there is no doubt we shall have an opportunity very soon of seeing a very large installation there, and at the Inventions Exhibition there is going to be a considerable amount of work done by the same system. After those two experiments we shall be in a position to judge whether economically it is good. In every other point, except perhaps the induced currents which the alternate current machines may create in telegraph wires and other circuits, there really seems to be no objection to the system. It is true there is a great objection to alternate current machines, but when we come to examine it, there is very little ground for these objections; if the leading and return wires are brought very close together, induction in neighbouring telegraph wires is small, and I really think that we ought to look—all electrical engineers ought to look—very closely into these experiments which are being made just now, for they really promise well.

Now let us go on to the other systems, and which are more analogous to those which we have been describing previously; and first, let us speak of the multiple series system. Here is a system, which I have alluded to, of multiple series on which there are two lamps on every series (Fig. 1, p. 1059). Now the trouble of that was, when it was first introduced, that if one of those lamps went out, the other in the series went out. In order to prevent that, it was suggested to bring a wire connecting the intermediate position to all the lamps in the circuit. Then if one goes out, the other does not, because it is fed by the current coming from the other lamps. The sketch shows that very well by the dotted line. Another example shows it in a different manner. There we go through successive pairs of lamps, the pressure gradually falling as we go along, and pass through the nine different series connected up. I do not know when this system was first proposed; it is very old, I believe. The first time that it was practically seen in action was, I believe, at the Paris Exhibition of 1881, when Mr. Edmunds lighted the Congress Salon by Swan lamps, the lamps all being fitted in multiple series in this manner. After that the most important experiments made were those by Mr. Preece, at Wimbledon, last year, when, in some experiments he made for the Commissioners of Sewers, he lighted up a large part of Wimbledon with incandescent lamps, all on the multiple series system; and quite lately we have had brought before our notice by Mr. Kierzkowski-Steuart an admirable account of the lighting of Temesvar, in Hungary, by means of a multiple series system like this, in a very remarkable article which appeared in a recent number of *Engineering*, giving a detailed description of the arrangements there, which had undoubtedly been worked out with very great care before laying down the installation. Now, the multiple series system is one which is admirably adapted to Temesvar, in Hungary, because it is only used there for street lighting, and the lights are always all required at the same time. But it is not suitable for house-to-house distribution, simply for the reason that if some of the lamps are put out, then the other lamps on the circuit have too much current. [Experiment to show this effect]. Now it would be intolerable, in a general supply of electricity, that when one house in a block of buildings was using rather less current than usual, other persons in that block should get far too much current; and that the next block of houses should receive so little current as was shown by these lamps (in the experiment) would also be intolerable. Various devices have been proposed for getting over these difficulties. I will deal with one or two. The first system which I shall speak of is one

which has already been put into practice, and it is undoubtedly a most ingenious principle. That is what is called the three-wire system, which Dr. Hopkinson originated. There we have two dynamos at the central station working in series, working through each other; that is to say, in the hydraulic analogy two pumps working in series, so as to send the water from the pumps at a very high pressure, if such a thing could be introduced into hydraulic engineering. The supply mains come from the extremities of two wires, but there is a third supply main which comes from the intermediate point and connected between the two dynamos, and the lamps are attached to branches which may come from the first main to the intermediate, or, as it has been called, the compensating main, and some of the lamps are attached to branches which are connected with the last main and the compensating main in the middle. We are able to use twice the pressure by using the dynamos in this way. Of course a great difficulty, as I have mentioned, would occur were it not for this central connection of the compensating wire; if there are more lamps in use in the first series than in the second series, then it would be necessary to drive the first dynamo so as to give a greater current than the second dynamo is giving, and then by adjusting the pressure of the two dynamos we are able to give a constant supply to both sets of lamps, and at the same time to work them in series. This line on the diagram is supposed to represent a point of very large consumption, such as a theatre, when the wires come, some from the first main and the compensating conductor, and some from the second main and the compensating conductor, but in about an equal number, so that if the lights of the theatre be put out of a sudden, the disturbance in one series of mains will be the same as in the other, and there will not be that change in the light shown you just now.

Now, as to the economy of this system. In the first place you will notice that, as I have arranged it here, which is the manner in which Edison has used it, the fall of potential is at the same rate as it is with the ordinary multiple arc distribution, therefore, according to this way, in which lamps are led off from two pairs of mains at every part, the distance to which these mains can extend is still limited, as it was in the multiple arc system, to 124 yards. But it would be equally possible to use only the first main and the compensating main, up to a distance of 124 yards, and then to use the compensating main and the second, the lower potential main for another 124 yards. Now, as to the economy. A great deal of exaggeration has been introduced in America into the accounts of economy in this system. It has been said that since you are using only half the current when you double the number of dynamos, therefore you half the size of mains; but then you have three mains instead of four, therefore, they say, you have a gain of 25 per cent. for that reason; but then, they also say, you have got twice the pressure you had before, and, again, you may halve your mains, and, altogether, they tell you, you can make a saving of copper of 62½ per cent. Now this may suit American financiers, but it is not electrical engineering. As a matter of fact, in the two cases, with an equal number of lamps, in place of having one dynamo and one pair of mains, I introduce two dynamos and three mains. I have half the current passing through that wire, and, therefore, I may have half the section of it, but there is no further reduction possible. I assume that I may take it for granted that the axiom which we worked out in the first lecture must be accepted as an axiom in all future time, that is, that to get economy in our mains we must use the most economical size of conductor possible. In that case the size of conductor is approximately proportionate to the current it has to carry; therefore, the total amount of copper you have to lay down is simply three-fourths of the mass of copper which would be laid down in an ordinary multiple arc system. At a meeting of gentlemen interested in electricity lately, this subject was broached, and I ventured to mention this point then simply because the originator was present, and I may say that Dr. Hopkinson thoroughly coincided with me in the views I have given you, so that the erroneous notion is evidently purely an American idea.

If we increase the number of wires from three to a larger number, then we increase the economy, but if all the wires are of the same size, then the limit of economy, the maximum economy would be to reduce the copper by one-half; but it is possible to reduce the compensating wire, and I should think it might be reduced to one-half, and in that case the limit will be one-fourth; that is to say, when you put a large number of series you will have about one-fourth of the copper which you have otherwise in a multiple arc system. However, if we wanted to be absolutely certain that our lamps would be in perfect working order, and

that our conductors would be of suitable size, perhaps it would be right that all these three conductors should be of the same size, because such a consumption might arise. I am not of this opinion; but suppose we say that then would come the question whether it is not possible to devise some other means of reducing the thickness of these intermediate wires—these compensating wires. And this is what Mr. Edison has accomplished, on paper at least. In a very interesting patent which he took out in 1883, he has described a means of switching over the lamps from one pair of mains to the other. Now I believe there is a great deal in this, and I believe it is possible in this way to make the householders themselves regulate their supply to a great extent. Just think what you do with your own gas. When you first light your gas, if your burners are as bad as burners usually are, your light flares, and you have to turn it down; after a time, when everybody else is using the gas, you have to turn it up again; then, late at night, when everybody has gone to bed and you are hard at work, you require again to lower it. If every householder had a switch, so that he could switch his own lamps on to one pair of mains or the other when he found his light dull, he would fiddle away with his switch, and in that case he would not only make his own light better but everybody's else, and every person in the district would be helping the others to acquire the right potential. No knowledge of electricity is required; no householder has to know what he is doing; he has simply to follow the natural instinct which a householder has of fiddling with his gas-jet until he gets it to work the best way possible and thus it is just possible that to some extent that may be of use. Mr. Edison proposed to use this system of switches with the three-wire system in combination with it, so that he will not get a perfect compensation by either the one or the other; by the combination of the two, he will get a perfect system and a perfect compensation. He has also proposed, in the same patent, to introduce automatic switches, switches which may be influenced by the pressure of these mains locally, or switches which may be influenced by the person in charge at the engine-house, so that wherever there is a deficiency of potential, lamps may be switched over. It is very probable that some development on this line may lead to important results. I have myself tried to extend the system a little, not in connection with the three-wire system, but in connection with the simple two-wire system.

I feel pretty certain that the lighting of a town from a central station must be done on some multiple series system until secondary batteries are so economical as to permit the general introduction of such a system as that in use at Colchester. The chief difficulty lies in the fact that each section receives the same current whatever be the number of lamps in use.

To obviate the excess of current, we might introduce conductors in those sections where it is required to carry off the excess of current. Thus we should save the lamps at the expense of energy. These conductors might be in the form of adjustible resistances acting automatically. This system is wasteful, but there are many cases where, at the present time, it is the most economical.

Another plan is to introduce in each section a secondary battery of low resistance, which shall act as a regulator. But secondary batteries are still rather expensive.

I have shown a diagram of multiple series arrangement, in which two wires go round the circuit with breaks occurring alternately in the two wires. If we alter the position of these breaks we can always have the same number of lamps on each section, and so avoid all excess of current, and all waste of energy. [Experiment shown.]

Now the time has come when we must conclude this course of lectures, and, in conclusion, I have only to say that I think you will all agree with me that when we attack the problem of electrical distribution in a serious vein, we find that it is rather simpler than it seems at the first blush. It has been well said by one of our most distinguished electricians that in the past the distribution of electricity has been the *crux* of electric lighting; it has been there that the difficulty has been. Undoubtedly the Electric Lighting Act has done an enormous deal to hinder electric lighting, but every electrician must admit that there has been a difficulty in the question of distribution; and I think you will all agree that the further we go into it, the simpler are the rules which guide us, and it is only that when schemes have generally been commenced in a slightly haphazard fashion, that difficulties of a serious character have seemed to present themselves. In every special district the engineer must use his discretion as to the kind of distribution which he is going to employ. But even in large districts, I think you will all agree that

the consideration we have given to it shows that it is a possibility to lay mains on economical principles which shall suffice for lighting large districts, if no undue hindrance is put in the way of enterprising undertakers by the authorities that are in power. The past history of electric lighting has chiefly dealt with the system which I first spoke of in my last lecture, the multiple arc system, but I do not hesitate to say that the future of electric lighting, on a large scale, will deal almost entirely with the systems which have been touched upon to-day. And especially I would draw attention to these different schemes and their value for the reason which I have already mentioned, that in the future we may have inventions in secondary batteries, or we may have other inventions but whatever invention there is favouring electric lighting, it will be of a nature suitable for using the thinner conductors which we should naturally lay down with any high potential system which I have spoken of this evening. Therefore, the engineer, in designing a system of mains, would have a natural bias towards such thin conductors, such high potential mains: for that reason he would advise it, as well as for other reasons. When we are able to use, as I confidently believe we shall, a pressure of 5,000 volts, we can diminish the thickness of our conductors to one-fiftieth part, and for a district of 50,000 lights we should only require a conductor of about an inch section of copper. When we are leaving the idea of masses of copper of the size of a man's body, and coming down to masses of copper an inch or even two inches in diameter, I think we are really coming to the question of practical electric lighting. And all this has been done—is not merely theoretical; it has been done to a considerable extent already, and that is the direction in which progress is being made at the present time.

I can only say that I hope the Parliamentary difficulties which have partly stood in the way of electric lighting in the past will soon be entirely removed, and that others will prosecute the question of electric distribution, so that we may be all thoroughly ready for it when we have greater facilities for electric lighting in the future, because there is not the slightest doubt that the question of distribution had not been sufficiently developed when the Electric Lighting Act was passed; and i we are ready in the future, when those great concessions which must be granted by this or a succeeding Government — because it is simple justice—when those concessions have been granted, let us trust that engineers will be ready, and be able to supply a scheme which is perfectly satisfactory.

The CHAIRMAN (Mr. W. H. Preece, F.R.S.), in proposing a vote of thanks to Professor Forbes, expressed his agreement with what the lecturer had said with reference to the danger of high potentials. He was quite sure that electricians were far more able to protect the public from even 50,000 volts, than gas engineers were to protect the public from explosions, or ordinary steam engineers from bursting boilers.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

GROUP XXVII.—CLOCKS, WATCHES, AND OTHER TIME KEEPERS.

By EDWARD RIGG, M.A.

Although, on the Continent, exhibitions of clocks, watches and chronometers, as well as of tools, &c., more or less closely related thereto, have been of comparatively frequent occurrence during the last few years, we must, in this country, go back to the Great Exhibition of 1862 to find a collection of horological appliances at all comparable with that which may now be seen at South Kensington, and such a comparison would bring into prominence the marked change that has come over many branches of the trade in the interval.

The present display brings prominently forward the one conspicuous change that has been gradually coming over the trade in recent years, the employment, whenever possible, of machine instead of hand-tools; and, although the very remarkable and elegant exhibit of the Waltham Watch Company cannot fail to impress the visitor as to the development of the use of machinery for watchmaking in America, it is none the less certain that the products of France, Switzerland, and this country afford unmistakeable evidence of the extensive use now made of machine-tools throughout the horological world. As instances of these, I may refer to the watches manufactured at Besançon, shown in the case of Antoine Frères; the Swiss products of Patek Philippe, Baume and Co., and the English exhibits of Wycherley, Hewitt and Co., Benson, and the English Watch Company.

Horology is at a disadvantage in an "Inventions" Exhibition, owing to the fact that the several classes of mechanism for the measurement of time have already for some time past been in a highly advanced state of development, and the goal aimed at—perfect

timekeeping—may perhaps be regarded as more nearly reached than is the case in the majority of the groups into which the Exhibition has been subdivided. Thus the inventions brought together have regard rather to methods of manufacture, details of construction, and the requirements of fashion, than to what must always be the primary object of the horologist. This must not be supposed to imply, however, that the period covered by the Exhibition has not been marked by any advance in this respect; on the contrary, not only in this country, but also abroad, a higher degree of adjustment is found in the better class of watches; and, while the cheapening of the commoner qualities has led to their distribution through lower classes of society, the average rate has probably improved.

Considering how long it is since the English public has had an opportunity of examining a collective display of timekeepers, it must be admitted that the impression conveyed by that in the Inventions Exhibition is one of disappointment. It is, doubtless, true that the necessity for novelty in the exhibits had much to do with the meagreness of the collection; but still more, it is to be feared, is this due to a certain lethargy which seems at the present time to hold possession of the trade in this country.

Although the exhibits are in no sense classified in accordance with the subdivisions of Group XXVII., given in the original scheme of the Exhibition, it will be convenient to adopt those divisions in the following report.

Turret clocks are poorly represented, there being but three exhibitors; the most important example of this class of work is contained in the Church Tower in the Old London street. It consists of a turret clock, smaller but similar in construction to that at the New Law Courts, provided with a double three-legged gravity escapement, and *remontoire* escapement, designed and constructed by Gillett and Co., of Croydon. The winding mechanism, designed by the same firm, is of novel construction, and is of the nature of a mechanical paradox, as there is no apparent means of preventing the clock running down as soon as the winding handle, which turns freely in either direction, is released. The explanation depends on the friction of the winding axis in the drum being sufficient to neutralise the tendency of the weight to turn the train of winding pinions in a reverse direction. The chiming machine presents points of interest, the most important of which is the arrangement for restoring the keys to their normal position, by an auxiliary mechanism, immediately after they have been released by the barrel pins. This renders it possible to employ smaller and lighter barrels, with seven tunes on each.

The only other exhibitors in this class are E. Dent and Co. (2,088), who show a turret clock with improved form of zinc and steel compensation pendulum; and W. H. Bailey and Co. (2,089.)

Chiming, quarter, and mechanical clocks, of both English and foreign construction, are represented. A. and H. Rowley (2,094) have the largest case of English construction, and it comprises complex examples of automatic figure work, &c. The cuckoo clocks exhibited by J. B. Beha and Söne (2,734), both through their English agents, Camerer, Kuss and Co. (2,117), and independently in the Foreign Court, exhibit marked improvements in this popular form of automaton, the note of the cuckoo being more accurately imitated, and the clockwork much improved by the substitution of movements made on the English model for the old wood-framed movements.

J. Harrington (2,114), well-known in connection with the bicycle and tricycle trades, exhibits a novelty in the use of metallic tubes for the sounding pieces of chiming clocks, of which a more extended use will probably be made in the near future.

Alarum clocks, which release the alarum once in twenty-four hours, and require to be wound but once a week, are shown by M. Samper and Co. (2,096), and by J. B. Beha and Söne, above referred to.

There are about a dozen exhibits of ordinary clocks, but in the great majority of cases they are of well-known standard designs, and call for no special remark. A beautifully made chronometer clock is shown by T. Mercer in the Horological Institute case (2,107); various makers exhibit clocks designed to show "24-hour" time, with a view to popularise the recent recommendations of the Washington Conference, a recommendation which has stimulated watch and clock makers, and others, to make very many applications to the Patent-office. G. Bendon and Co. (2,098) show an improved keyless clock, in which a winding arbor passes through the minute wheel; when required for winding, it can be withdrawn and bent twice to form a cranked handle, which serves to wind up both going and striking mainsprings. The exhibit of the De Gruyter Clock Manufacturing Company (2,097) possesses at present a scientific even more than a practical interest, as the torsion of a fine steel band is applied in their clocks to the measurement of time, and this is probably the first application of torsion to such a purpose. Much has been done towards the cheapening of carriage clocks by E. Sauze (2,731), who has an extensive display in the French Court.

The only remaining point to which reference need be made in connection with ordinary clocks, is the application of machinery to their manufacture. In the Horological Institute case (2,107) J. Greenwood and Co. show some movements produced in this manner; but the exhibit of A. Légé and Co. (2,130) in Group XXVIII. is of more general interest, as it contains the punches, milling tools, &c., used, as well as specimens to show the successive stages of manufacture of the several parts. The system adopted for producing any number of identical pairs of clock pallets shows great ingenuity.

Workmen's time-checking and other tell-tale clocks are exhibited by several firms. Of the first class, that designed by N. C. Firth (2,099) is un-

doubtedly the most complete, as it not only subdivides the time during which workpeople are arriving into any desired intervals, but also gives the precise order in which they arrive, thus facilitating the detection of fraud in case two tallies are introduced by a single operative. This is effected by allowing the brass tallies to fall, each on the top of the one that precedes, thus forming a rouleau in a vertical tube, while at intervals of, say, five minutes, the clock automatically drops a copper tally above those already in the tube.

Dent's portable tell-tale (2,088) is probably the best watchman's clock exhibited. It only involves the use of a single clock, which has to be placed successively in fixed cases at the several stations visited, and is carried by the watchman; a card within receiving an impression from the die in each fixed case.

Perhaps the most noteworthy advance that has been made in connection with stationary timekeepers during the last quarter of a century is the more extended adoption of time signalling and the controlling or synchronising of clocks; but it is to be regretted that the exhibition shows little evidence of this. The taking over of the telegraphic service by the Post-office in 1870 has contributed greatly to this extension, and a display of the system by which the Greenwich daily signals at 10 and 1 o'clock are distributed to many hundreds of stations throughout the country by the Telegraph Department would have possessed much interest. The Standard Time and Telephone Co. (2,108) show what is usually known as Lund's system of synchronising clocks (by mechanically bringing the minute hand to the hour through the agency of an electro-magnet placed behind the dial), a system which has been extensively brought into use in London and elsewhere.

C. Shepherd (1,304) exhibits in the electrical gallery a novel form of standard electric controlling clock and other electric clocks in unison with it. This maker's long experience in the application of electricity to timekeepers is a sufficient guarantee of their excellence.

The exhibits of E. Dent and Co. (2,088), and V. Kullberg (2,118) contain chronometers provided with galvanic contact apparatus of different design, but both of beautiful construction. In that shown by the latter firm, the passage of the current is rendered as nearly as possible certain by an arrangement of studs and delicate springs, which gives contact at three different points, the circuit being closed once each second by the teeth of a wheel, mounted on the same axis as the fourth wheel, coming into contact with a ruby pin.

In Dent's chronometer the supplementary wheel is on the escape-wheel axis, and its movement is employed to break a constant circuit momentarily, instead of making it for a similar period. This secures greater certainty of action, and, as the deflection of the spring takes place immediately after an impulse has been given by the escape-wheel tooth to the balance, it is found possible to transmit these seconds signals without prejudice to the rate of the chronometer.

The greater number of the exhibitors in the horological group naturally come under class 146—watches and chronometers. There are 24 such independent exhibitors, besides 13 who show in the case of the Horological Institute, but of these 37 only 9 include chronometers in their exhibits. These last are in the English section, and comprise such well-known makers as V. Kullberg (2,118), E. Dent and Co. (2,088), T. Mercer, J. Hammersley, H. P. Isaac, in the Horological Institute case, and Frodsham and Co. (2,084). Beyond the galvanic contact attachments, to which reference has been already made, the chronometers exhibited call for little remark. The ordinary compensation balance, with or without slight modifications to correct for the variation, commonly known as the "middle temperature error," still seems to be the most generally employed, and it is probable that the recent introduction of palladium balance springs, requiring as they do less compensation than those of steel, will tend still further to establish it, by rendering an auxiliary compensation less necessary. An entirely new departure in the installation of chronometers on board ship is taken by V. Kullberg, who replaces the ordinary boxes containing the chronometers supported on gimbals, by a strong vertical column, from the top of which flexible arms extend radially, a chronometer in gimbals being suspended from the extremity of each by a rod.

The radical changes that have been made since 1862 in pocket watches, may nearly all be traced to the more extended use of machine tools in their manufacture. Thus a going-barrel watch lends itself more readily to such a system than one provided with fusee and chain, and has become much more general; this change in its turn facilitated the adoption of keyless mechanism, and, while materially simplifying the construction, has, instead of reducing, led to an increased accuracy in the timekeeping of the ordinary watch. This result, however, is brought about, not in consequence of any theoretical advantage possessed by the going-barrel, which must be considered the inferior in this respect, but rather because of the bad quality of the fusee work in the cheap watches under consideration. In the going-barrel watch, more attention is now paid to the isochronal adjustment of the balance-spring, in order to counteract variations in the motive force due to the absence of a properly adjusted fusee; but for the highest class of work, both these means of adjustment should be available.

One further gradual change in watches should be noticed before referring to individual exhibits. This is the more general adoption of the lever escapement by Continental makers, a change which the demand for high-class timekeeping qualities has brought about. It seems curious that the horizontal escapement, the invention of an English horologist, Graham, should

be so exclusivety identified with foreign work, whereas the lever, whose earliest form came from France, should have been so steadily advocated in this country for more than 100 years.

Although many firms used machine tools prior to 1862 for the manufacture of parts of watches, the factory system may be said to have assumed commercial importance in connection with this industry since that date. Switzerland led the way in this matter, but it is in America that the capital requisite to start this system on a scale sufficiently extensive to undertake the manufacture of all the parts of a watch has been forthcoming. Foremost among the American companies stands that at Waltham, whose exhibit in the American Court (2,521) has formed one of the principal points of attraction since the Exhibition was opened. This is not the place to enter into a minute account of the beautiful display which has already been very fully discussed in the technical journals, but this report would be incomplete without something more than a passing reference.

There are twelve machines, mounted on a bench, and driven by a system of countershafts, designed for making screws; roughing-out, finishing, and polishing pinions; escape, train, and keyless wheel-cutting machines; a dial foot cutting machine, and a lathe for repairing purposes. These are attended by male and female operatives, and have, in nearly all cases, an automatic stop arrangement, thus enabling a single attendant to take charge of several machines. Although that for producing watch screws, working as it does automatically, and only requiring to be fed with steel wire to turn out about 4,000 finished screws per day, is unquestionably the most attractive to the ordinary observer, a watchmaker will probably be more interested in the machine for cutting the teeth of lever escape-wheels, in rouleaux of fifty at a time. On a separate counter, a beautiful example of automatic machinery is used for drilling and tapping compensation balances, and two delicate instruments may also be seen for gauging the strength of balance-springs, and for ascertaining whether the vibrations of each balance, with its balance-spring attached, are isochronal with those of a normal balance. A case of finished watches, one showing the successive stages of manufacture, and a model of the Waltham Watch Factory, complete this most interesting exhibit.

In the English section only one firm, Wycherley, Hewitt and Co. (2,090) makes a display of machines used in the manufacture of watches, but as they are not in action, many visitors are likely to pass them by almost unobserved. It is matter for sincere regret that English makers have not made some effort to show how far the use of machinery has advanced in this country, as a widespread opinion exists that America is the only country in which any advance has been made on the old hand system of manufacture. In point of fact, there are numerous factories in London and the provinces where machinery, comparable with that in use at Waltham, is extensively employed, though of course none on so large a scale, or comprising so many branches of the trade under one roof. Wycherley, Hewitt, and Co.'s exhibit comprises a complete series of the tools they employ in making one portion of the movement, the barrel and its arbor, as well as a number of parts made on the interchangeable system. The tools are of heavier build than those employed at Waltham, and no attempt is made to carry the automatic system into such elaborate detail. All the tools are designed and made by the exhibitors, and it should be explained that they only make what is known in the trade as the "movement," leaving it to be converted into a finished watch on the old hand system, whereas in America all these succeeding operations are undertaken by the same firm.

Although there are no other exhibitors of watch-making machinery, a special feature of "machine-made watches" is, as already indicated, made by several firms; Antoine Frères (2,732), Patek Philippe and Co., and Baume and Co. (Switzerland), J. W. Benson (2,085), English Watch Co. (2,111), and D. Buckney in the Horological Institute case. The watches vary much in quality, those of D. Buckney, Patek Philippe and Co., and Antoine Frères taking the highest rank; the two latter firms also show several of those minute watches, in the manufacture of which some Continental makers have attained so high a degree of skill.

High-class pocket timekeepers are exhibited by several other makers of repute. Among these may be mentioned V. Kullberg (2,118), J. Hammersley, H. P. Isaac, and Lewis Donne in the Horological Institute case, E. Dent and Co. (2,088) in the English, and by Weidemann and Goy et Blanc in the Swiss section.

There can be little question that the system recently established by the Kew Committee of the Royal Society for the rating of watches at their Observatory (whose unpretending exhibit, 2,091, is one of the most interesting in the Group) will do much to encourage this branch of the industry, both by stimulating the manufacturers to pay more attention to the adjustment, and by providing the public with a standard of accuracy which has never before been available in this country. Indeed, the value attached to the Kew certificates is sufficiently evidenced by the display of them in several cases in the Exhibition, and much of the progress that has been made in accurate timekeeping on the Continent is attributable to the similar trials that have been held for many years at the Observatories abroad.

The case exhibited by the Horological Institute (2,107) contains, besides excellent examples of work by some of the best known manufacturers in the clock, watch, and chronometer trade, a most interesting collection of the work done by pupils in the School of Practical Watchmaking, which has for some years existed at the Institute. No less than twenty pupils have taken part in this exhibit, and the collection

reflects much credit on both teachers and taught. The fact that such a school has been established is of itself important evidence of progress since 1862.

A few minor changes in detail may be summarily referred to. The great extension in the use of the dynamo-electric machines for the production of the electric light and other purposes, has necessitated the production of watches not liable to be affected by magnetism, and several such may be seen. Again, the recommendations of the Prime Meridian Conference relative to the division of a day into twenty-four hours instead of into two sections of twelve hours each, has led inventors to design many forms of twenty-four-hour dials for watches as well as for clocks. Keyless mechanism has been much more generally adopted both for the cheaper and highest qualities, chronographs have become more common, and the crystal glass, originally introduced by J. Walker (2,092), has much advanced in public favour.

It remains briefly to consider the exhibits coming under class 147—tools, &c. The few machine tools shown have already been briefly referred to. Grimshaw and Baxter (2,086), Haswell and Sons (2,093), and E. Gray and Son (1,651), are the only firms to represent a very important trade—that in hand-tools, lathes, mandrils, &c., and "materials." The case of the first-named firm is the largest and most complete, comprising as it does an extensive collection of the celebrated Whitcomb lathes with their various attachments, many of the ingenious and well-made lathes and tools for various special purposes, made by G. Boley, of Wurtemberg, and some excellent specimens of the work of our own tool-makers at Prescot, in Lancashire, long the home of this branch of the trade in this country. These together form the most complete display of high-class tools for this class of mechanical operations that has yet been brought together. The Whitcomb series are unquestionably the most highly finished tools within the reach of watchmakers. Those made by Boley, on the other hand, being less elaborately finished, are proportionately less expensive and yet satisfy all requirements of the trade. These two firms have greatly helped to bring about the much needed reform in the tools used by watchmakers that has occurred in recent years, and a very cursory survey of either of the exhibits (2,086, 2,093), will make the reality of this change manifest to anyone acquainted with the tools still in use in many shops. It is disappointing to an Englishman to find all the progress taking place abroad, and the few excellent tools from Prescot amply prove that the ability still remains in Lancashire; but the tool makers seem to be held back by a stolid determination not to advance one step with the times.

A corresponding improvement may also be observed in the quality and finish of the "material," or detached parts of watches and clocks required in their manufacture or repair, many parts being now purchasable in a finished state, which but a few years ago could only be obtained in the rough, a change which, again, is mainly due to the "interchangeability" secured by the use of machinery. The case of Haswell and Sons contains an extensive assortment of such material.

A few instruments for special purposes, exhibited apart, must not be overlooked. One is R. Bridgman's "Anglemeter" (in the Horological Institute case), for measuring all the angular movements and data in connection with the lever escapement, an instrument of very beautiful construction, and much value; and another is Kullberg's device for maintaining the temperature of an oven, &c., constant, as when adjusting chronometers. This is secured by enclosing a bi-metallic strip in a glass tube within the oven, and arranging it so that, when deflected, the free end opens, more or less, an orifice through which the gas supply passes. A case from the Polytechnic Institute (1,172), in Group XXVIII, contains two instruments devised by J. Herrmann, the one termed a "trigonograph," for setting out the calliper of a watch and other analogous purposes, and the other a "graphical quadrant," more especially adapted for work of larger dimensions. Both involve the use of polar co-ordinates for expressing the position of the several points.

An unpretending but important exhibit to all engaged in mechanical work is the last to which reference shall be made. This is a small case from the General Post-office, containing specimens of the new standard sizes for small screws—that is, screws ranging from one-quarter inch (the smallest Whitworth screw in general use) to 1-100th inch—recently recommended by a Committee appointed by the Mechanical Section of the British Association. This system is being adopted by the postal authorities for all telegraphic instruments in use in this country and the colonies. It is much to be hoped that clock and watchmakers may see their way to adopt this series of approved screws in place of the varied plates in use, the inconvenience caused by which is similar to that felt in the engineering profession before Sir Joseph Whitworth established his standard threads in general use. Its adoption by the trades interested will be greatly facilitated by the fact that in Switzerland, the main source of our supply of small screws and screw-plates, the manufacturers have just adopted an identical series.

The number of visitors to the Exhibition for the week ending Tuesday, 13th October, was 137,389. Total since the opening, 3,275,324.

MEASURES FOR IMPROVED PHYSICAL TRAINING.

By Edwin Chadwick, C.B.

The *Times* has been good enough to insert a letter of mine on the Trades Unionists and on drill in schools, I would add some important facts, subsequently received, for the information of the members of the Society on the progress made on the subject:—

The resolution adopted at the recent Trades Union Congress at Southport, relative to the practice of the military drill in Board schools, was to this effect:—"The Congress felt constrained to protest against drill as a cunningly devised scheme by which military authorities and a number of Board schools have been, step by step, preparing the way for the pernicious Continental system of conscription."

The publication of this resolution may serve as an opportunity for giving to the wage classes, as well as to others, such information as may conciliate general support to the movement for the physical training of children. The War Department, it may be stated, is entirely innocent of any such designs as the resolution attributed to it.

As Chairman of the Education Committee of the Society of Arts, I may claim for that body the initiation of the movement for the introduction of the military drill in elementary schools. I may state that its main object was not military but civil—to so improve the training of children as to enable them to meet the increasing demands for more fit labour needed for the advancement of Arts, Manufactures, and Commerce. Let a trade unionist consider what the military drill itself will do for his son. In the first place, it improves his walk, and enables him to move from point to point quicker, with the same amount of force. Let the difference of the set-up and movement of drilled and undrilled boys be observed. The drill makes him tread more evenly, and saves shoe leather. School teachers, who have been trained in the military drill, state that they find they now save a pair of boots a year by not treading unevenly as they used to do. The even tread saves trousers by throwing up less mud upon them. These life-long economies will be comprehended by mothers through the tailor and the shoemaker. Trades unionists may slight them as not being in accordance with their policy of doing "what is good for trade." But the drill conduces to qualities of a high moral order and value denoted by the term discipline; patience, order, self-restraint, prompt and exact obedience. Children so trained learn to move quickly together, and to pull together, and exert force with fewer hands. If anyone will go into the large Lambeth Poor-law School, which is a well-drilled school, he will see in the quickness of changing classes, with order, the qualities displayed in the large manufactory, which make the children worth more, and they do get more wages. Employers have declared that the volunteers so drilled are worth several shillings a week more than the undrilled. On our pressure, and mainly for the qualifications for civil work, the Privy Council was got to make an allowance for a drill-master in the schools, and there are now more than a thousand of the National as well as the Board schools, in which the military drill is introduced. And all the education inspectors bear strong testimony to the improvement produced by it, on the education of the schools. There is, however, drill and drill. Drill-sergeants were generally taken for the schools because there was generally no one else to be got. Professor McLaren, of Oxford, has made large accepted improvements on the ordinary drill, which have yet to be made generally prevalent in schools. In the large district Poor-law schools, in the industrial schools, and in reformatories, now comprising upwards of forty thousand children, all of which are based on the half-time principle, and it is necessary to call in the aid of workmasters, carpenters, smiths, shoemakers, tailors, sailors for exercises on the ship's mast, farm bailiffs for exercises in tillage on the school farm, stokers for work at the steam engine, and teachers, &c., and for the girls' work at the laundry or in cooking; to impart aptitudes to the hands for whatsoever industrial work may turn up. On a recent visit I made to the large Manchester Poor-law Half-time School at Swinton, the master confirmed the conclusion from practical experience, that the general result of the half-time principle, so worked out, will be to impart to two the efficiency of three ordinary labourers for productive industry, and will proportionately augment their money value as labourers. It is necessary to give such amounts of practical instruction in these institutions to clear the subjects from the hereditary, vagrant, or the pauper taint, as it now does, to the extent of upwards of ninety per cent. of children of the lowest type in the towns. But it is a training beyond what can be got by farmers or middle-class persons outside of the institutions, and I see what appear to me strong reasons why the middle classes should be allowed to send their children in as day scholars if they choose, until distinct and special provision can be obtained. It is to be noted, that the cost of the mental training power and of the physical training power together, with higher salaries than in the small schools, is not above one-half the average cost of such teaching and inferior training as is given in the long-time schools; or about £1 per head per annum. Of this about one-third may be set down as the cost of the physical training, or about a penny halfpenny per week, including teaching swimming. The attention of the wage classes may be directed to the conclusion from existing experiences that, by the payment of about a penny halfpenny per week for four or five years, an increased value may be imparted to his son to and for himself of one-third greater efficiency, and of proportionately augmented wages for the whole of a prolonged life. Not long since I conveyed an offer to the district school at Anerley for the artillery, but none would now volunteer for the army. Immediately the boys left school they would get such wages as 12s. a week, and as they grew older and stronger had an early prospect of 24s. a week and more as wages. At Manchester some of the lads became foremen early. In mental improvement these half-time schools of mixed physical and mental training are generally in advance of the long-time schools, which are almost solely for mental training. Children

who have been in the half-time schools from infancy get through the fourth standard, on the average, by the age of about nine years and a-half, with children, be it borne in mind, of the lowest type; and that at half the annual cost of training as well as of teaching power, of the long-time schools generally, where the children do not on the average get through the fourth standard in less than ten years and half, or eleven years, or later. This will be ascribed to the fact of these district schools having always the children in hand. But the like results are obtained at large graded open schools for day scholars, such as the one at Faversham. Of the pauper children in the parish schools of the metropolis, formerly examined under our Poor-law Commission of Inquiry, only a small minority reached inferior places; the rest were found on the streets as beggars or vagrants, or in the prisons as delinquents. Excepting idiots, or the bodily disabled, 90 per cent. of those trained in the district half-time schools are accounted for as got well to the good. The sanitation in these institutions is pre-eminent. Lord Cranbrook, the other day, speaking in favour of the boarding-out practice, stated that the death-rates were only eight in a thousand. Our information gives more than that. But if his lordship examines, as it is to be hoped he may do, he will find that of the children brought in without any developed disease upon them, and confining the results to the diseases of spontaneous origin within these institutions, the general death-rates are under three per thousand, or about one-fourth of the death-rates of children of the same ages of the outside general population, and he will see causes for the wide application for this great result of sound sanitation.

It is to be observed a great recommendation of the preventive physical exercises is that they contribute largely to the happiness of infantile and juvenile life. I presided at an exhibition of some of these exercises, displayed by Miss Chreimans, at Exeter-hall. I had Dr. B. W. Richardson beside me, and found that he could assign a distinct preventive or curative effect to almost every separate movement which the children were exercising joyously. At the Manchester School Board school I was informed that those who had been remiss in their attendance at the mental work were not allowed to join the physical exercises. At one district school where there was the mast drill, the master only allowed the good boys to go upon the mainyard arm, and his very best or favourite boy to be mastheaded.

With the progress of physical training, the number of desertions from the district institutions has progressively diminished.

We find, however, on examination, large increasing serious demands for special sanitary organisation, for the prevention of the deterioration of the physical condition of the general population. Lieutenant-Colonel Moody, of the recruiting service, states in his last report that 428 out of every thousand of recruits applying for enlistment were rejected on grounds of bodily unfitness for Her Majesty's service. Let the trades unionists consider that this extent of unfitness for military service represents a greater amount of defects amongst children and persons of their own class, that renders them less fit for the endurance of productive labour, and of wages for it in the civil service. There are, however, other largely increasing demands for the sanitary service, of prevention in the juvenile stages, which I shall describe hereafter. In the last census for the United Kingdom, there is an enumeration of 30,000 blind. By Mr. Brudenell Carter and other specialists it is held that, by competent attention in the infantile or elementary school stages, a large amount of this suffering—some go so far as to assert two-thirds—may be prevented. By the census there are in the United Kingdom 112,000 lunatics. Physicians, heads of the asylums, declare that, as a class, the insane are of very low physique, and that by early physical training a large proportion of this calamity may be averted. From the late Dr. Guy, who was for a long time the chief physician of the Prisons Department, I received a letter of reminder that it might not be overlooked that, as a class, the population of the prisons (amounting to 28,000, and 47,000 as at large, who chiefly keep up that population) is of low physical and low mental condition; and that a great deal of punishment is in fact inflicted on conditions almost of insanity which early and good physical training would largely reduce. The attention of the Swedish Government has been given to special measures of sanitation for the reduction of the masses of evil arising from defective physical training. At Stockholm every child on its admission to school is diagnosed by a first-class specialist in sanitation, who writes a prescription for the remedy of any special defect he may find as beyond the ordinary preventive exercises. A child, say, is very flat chested, and he prescribes an extra dose of those exercises which open the chest, and he gives the prescription to an appointed specialist, who is charged to see constantly to its due application. The lead of Sweden in this branch of preventive sanitation is now being followed in other States on the Continent and in Belgium, especially at Brussels.

It is proposed, as a first step, to recommend to the Government the appointment of a college for the physical training of boys and one for girls, commensurate with the colleges for mental training, but distinct from them, and under the preventive health service. It is thought that some of the funds from the lapsed charity bequests for the benefit of poor children may be fairly applied to this purpose.

The trades unionists may be invited to send deputations to visit the schools where the drill and other exercises are given (and to take their wives with them to see the treatment of the girls and infants there), when their support may be anticipated to measures for the extended application of what they will witness, for the better promotion of the health, strength, and working ability, and the advance of the earnings of their children.

The resolution of the trades unionists for an increase of the sanitary inspectors may be regarded as displaying an opening perception of the importance of sanitary organisation, in which they are the most deeply interested.

(*To be continued.*)

Obituary.

F. MATHEW.—Mr. Francis Mathew, M.Inst.C.E., who died in London on the 30th ult., aged 54, was elected a member of the Society of Arts in 1883. He went out, while quite a young man, to India as an engineer in the service of the Bombay, Baroda, and Central India Railway Company. He was rapidly advanced to the position of chief engineer, an office which he finally held in conjunction with that of agent and general manager for the company at Bombay. While resident in Bombay, Mr. Mathew took an active part in the management of the municipal affairs of that city, and served for several years as a member of the town council. Mr. Mathew was also frequently consulted by the Government of Bombay regarding the construction of docks, waterworks, and sanitary improvements in the capital of Western India. Returning home from India in 1882, Mr. Mathew became consulting engineer to the Bombay, Baroda, and Central India Railway Company in London, an appointment which he continued to hold up to the time of his death. Mr. Mathew was a nephew of the celebrated Father Mathew.

General Notes.

LUMINOUS PAPER.—A simple recipe is given in *L'Illustration* for making luminous paper. The composition consists of forty parts ordinary paper pulp, ten parts water, ten parts phosphorescent powder, one part gelatine, and one part bichromate of potassa. The phosphorescent powder is composed of sulphides of calcium, barium, and strontium, well ground and mixed together. The bichromate of potassa acting on the gelatine renders the paper, which is manufactured in the ordinary way, impermeable.

LARGE VINE.—The largest vine in the world is said to be one growing at Oys (Portugal), which has been in bearing since 1802. Its maximum yield was in 1864, in which year it produced a sufficient quantity of grapes to make 750 litres (165 gals.) of wine; in 1874, 665 litres (146⅓ gals.); and in 1884, only 360 litres (79¼ gals.) It covers an area of 494 square metres (5,315 sq. ft.), and the stem at the base measures two metres in circumference.

XANTHINE.—The *Central Blatt für Textil Industrie* calls attention to the above new reddish-yellow colour which is being introduced by the *Société Anonyme des Matières Coloronantes* of Paris. It dyes easily on wool, cotton, silk, &c., in a neutral bath or in a bath containing small quantities of vegetable acids, such as acetic, oxalic, or tartaric acid. Cotton is mordanted with tannin and sumach. Tissues of wool and cotton mixed (or silk and cotton) can be dyed in a single bath after the employment of such mordants. This colouring substance readily unites with fuchsine and Paris violet, and is dyed in the same way. An unlimited number of shades can, therefore, be produced by this combination.

A MARITIME CANAL AT ROME.—A scheme for making Rome a seaport town by means of a ship canal, has been recently brought before the public by an Italian engineer, Mr. Gabussi, who, during the construction of the Suez Canal, was engaged under M. de Lesseps. This proposal is considered by competent authorities to be perfectly feasible. The canal, which would be 25 kilometres (15½ miles) long, would be made from near the church of St. Paul to the sea. Its width at bottom is proposed to be 22 millimetres (72 feet), and with a depth of water of 8 millimetres (26 feet), so that it would be navigable for ships of war, and merchant vessels of large tonnage, which would be able to discharge their cargoes at the gates of the city. The cost of this undertaking is estimated at 185,262,000 francs (£7,410,480) sterling.

PRODUCTION OF SILK OF THE WORLD.—The syndicate of silk merchants of Lyons publish the following statistics of the silk production of the world, which has been for the last three years as follows:—

	1882.	1883.	1884.
WESTERN EUROPE.	kils.	kils.	kils.
France, including Corsica and Algeria	772,000	611,000	483,000
Italy	2,370,000	3,200,000	2,810,000
Austria and Hungary	125,000	180,000	142,000
Spain	110,000	95,000	85,000
	3,377,000	4,086,000	3,520,000
LEVANT.			
Brussa	90,000	180,000	185,000
Salonica, Adrianople, Volo	80,000	110,000	95,000
Syria	235,000	290,000	230,000
Greece	20,000	20,000	20,000
	425,000	600,000	530,000
CENTRAL ASIA.			
Georgia, Persia	250,000	250,000	200,000
EASTERN ASIA.			
China, Shanghai	2,402,000	2,121,000	2,680,000
,, Canton	1,052,000	900,000	693,000
Japan, Yokohama	1,436,000	1,555,000	1,484,000
India, Calcutta	456,000	536,000	208,000
	5,346,000	5,112,000	5,065,000
Total production	9,398,000	10,048,000	9,315,000

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Proceedings of the Society.

CANTOR LECTURES.

THE MANUFACTURE OF TOILET SOAPS.

By C. R. Alder Wright, D.Sc., F.R.S., F.C.S.

Lecture I.—Delivered May 4th, 1885.

Distinction between Toilet Soaps and Household and Scouring Soaps, &c.

Most people, at the present day, have a moderately clear conception of what is meant by the term "a piece of soap," the idea conveyed being that of a substance having the qualities of a lump of ordinary household "yellow soap," or a tablet of "brown Windsor," or of "transparent" soap, or of other choice and more expensive varieties, all possessing in common the property of giving a lather with water, and of assisting the removal of dust and dirt from the hands, &c., when rubbed with water and the soap, so as to form the lather in contact with the skin or the article to be cleansed. Most people know, too, that, instead of soap, various other substances can be used for the purpose of facilitating the removal of grease and dirt from the hands or household articles, &c.; such as wood ashes (either as such, or purified by treatment with water, straining clear, and evaporating the solution until a solid mass of "potashes" is left), the ashes of certain seaweeds and maritime plants (*kelp*, *barilla*, &c.), "spirit of hartshorn" (solution of ammonia), and so-called "Scotch" soda or soda crystals (washing soda), all of which substances belong to a class of bodies chemically classed as *alkalies*,* and differing entirely in character from certain vegetable juices (*e.g.*, the "hyssop," the "soapwort," &c.), and various earthy and clayey matters (*e.g.*, "fullers' earth"), occasionally used for the same kind of purposes. Soaps, in point of fact, are simply alkalies, the properties of which have been, to some extent, diluted and modified by the chemical action on them of various fatty and oily matters; and for our present purpose soaps, as a whole, may be divided into two main ranks, viz., those which are intended for the cleansing and scouring of household furniture, floors, linen, &c., or for analogous purposes in the arts and manufactures (*e.g.*, for cleansing woollen or cotton textile fabrics, before dyeing or subsequently); and those which are prepared with the intention of being employed for personal ablution, *i.e.*, which are intended to be brought in contact with the human skin for the purposes of cleanliness. The latter class, conveniently designated as *toilet* soaps, essentially differ from the former only in the quality of the materials used in their manufacture, and the care and skill employed in so conducting the operation and proportioning the ingredients to one another, or in subsequently purifiying and refining the crude product, as to obtain, as the final result, *a material in which the alkali originally used has been all but perfectly transformed into true soap*, leaving none uncombined with the fatty matters employed; in other words, a "toilet" soap is essentially a variety of soap *made from choice selected kinds of fatty matters* judiciously combined with alkalies in such fashion that *the product contains practically no alkali in excess*, generally spoken of as "free alkali." Some of the ordinary household, laundry, scouring, and manufacturers' soaps in everyday use only differ from toilet soaps proper in that they are made with cheaper and coarser materials, and in a somewhat rougher way; but there are also in use a number of scouring soaps which are purposely made intensely alkaline (by employing alkali in excess during manufacture, or by mixing with the crude soap, before solidification, certain proportions of alkaline matters), so that they may naturally possess a high detergent power;† soaps of this

* From the Arabian term *Al Kali*, applied to a particular plant (glasswort), the ashes of which abound in "potash," and have consequently been employed from the earliest ages as a detergent for laundry operations, and for the manufacture of glass, &c.

† "Cold water" soaps, "marine" soaps, "soft" soaps, and certain other kinds largely impregnated with silicate of soda, &c., are familiar examples of this class of products.

class are obviously wholly unfitted for the special purposes for which toilet soaps are intended, because the excess of alkali purposely introduced renders them far too corrosive in their action upon tender and sensitive skins, especially infants and delicately nurtured ladies. Persons with tough, sound, healthy skins, however, can often use even the most alkaline scouring soaps without material injury (at any rate when not too frequently applied). Accordingly, there are to be found in the market a large number of soaps by courtesy designated "toilet" soaps, and usually sold at relatively low prices, the only claims of which to the title "toilet" soap lies in the fact that they are mechanically cut and stamped into tablets convenient in size and shape for washing the hands, &c. Thanks, probably, to the hardening effect of the gloriously uncertain British climate, the number of persons in this country whose skins are so tough that they can habitually use these alkaline soaps without suffering severely in consequence is sufficiently great to enable a considerable number of soap tablets to be sold, the characters of which are only to be compared with weak mustard plasters, or diluted blisters, so far as their rubefacient and generally irritating action is concerned; but the more sensitive and tender-skinned of the population suffer greatly from the use of such soaps, and, in consequence, of late years a rapidly increasing demand has sprung up for certain superior kinds of foreign-made soaps free from these defects. Unfortunately, price is not by any means necessarily a guide to quality in this respect; and so far as alkalinity is concerned, many of the more expensive soaps are quite as bad as most of the cheapest class, although they, at any rate, possess the advantage of being made from less coarse fatty matters, and being more attractively scented and otherwise finished.

The general characters of toilet soaps, as they exist in trade, then, may be briefly put thus: the better classes, truly deserving the name, are superior varieties of soap made from selected materials, with special precautions to avoid alkalinity, and in some cases improved and rendered more attractive in appearance by perfuming, tinting, and working into the form of highly finished tablets; whilst the lower grades are either made from good materials, but in such a fashion as to be highly alkaline, or are simply ordinary household and laundry soaps (or different varieties of such blended together) made from commoner kinds of material, but more or less improved in appearance whilst working into tablet form. Viewed from this standpoint, it is, unfortunately, the fact that a large proportion of the tablets sold under the name of "toilet soaps" in this country are quite unworthy of that name, being much better suited to the laundry than for the use of delicately nurtured persons as an application to the skin.

Early History of Soap-making Processes, and the Nature of the Chemical Changes taking place therein.

Although the use of wood ashes, and probably other natural alkaline substances, as aids in cleansing clothing, &c., has been known from a very ancient period,* still no certain historical reference to the products of the combination of these alkalies with fatty matters appears to be extant long prior to the Christian era. Hyssop and other vegetable extracts, fullers' earth, and certain natural alkalies (more especially *natron*, an exudation or efflorescence from the soil of certain localities, or a product of the evaporation of certain natural waters) were known to the early Jews, various references thereto being made in different portions of the Old Testament; but in all probability the materials actually referred to in those passages where the English translation mentions "soap" (or rather "sope") were not the fatty combinations now known by that name. Thus the passage in Jeremiah ii., 22, "For though thou wash thee with nitre, and take thee much sope," doubtless refers to *natron*, and not saltpetre;† whilst *borith* (translated sope) more probably refers to wood-ash lye. Again, in the Homeric description of primitive laundry operations in the open, no mention is made of any substance that could

* The use of wood ashes, and indeed of ashes of other kinds, for scouring purposes, is far from extinct at the present day. A remarkable illustration of this was afforded in Rome a few weeks ago, according to a correspondent of the *Times*. An ancient tomb being dug up, a quantity of ashes found therein was appropriated by a workman, and sent home to his wife for use in washing; these ashes, it subsequently appeared, were the cremated remains of the Emperor Galba, there deposited some eighteen centuries ago. "To what base uses we may come!"

† The above was written before the appearance of the Revised Version, in which the passage is made to read, "For though thou wash thee with lye, and take thee much sope." On the other hand, the passage in Proverbs xxv., 22, referring to "vinegar upon nitre," remains the same in the Revised Version (save marginal note, "or *soda*"). The entire force of the illustration is lost by the use of the word *nitre*—*i.e.*, saltpetre—for this salt produces no visible result of any kind on intermixture with vinegar; whereas natron—*i.e.*, crude carbonate of soda—developes a copious froth, the hollowness and rapid subsidence of which is in keeping with the effect of singing "songs to an heavy heart."

be identified as soap of any kind. In the time of Pliny, however, it appears to have been discovered that tallow and wood ash lye would form a cleansing compound, such a substance being described by this author; whilst at the period of the destruction of Pompeii, the manufacture of soap had attained to a considerable degree of completeness, judging from the discovery, in the remains of that city, of what appears to have been a well furnished soap factory.

Not till the present century, however, was the character of the chemical action taking place in the conversion of alkalies and fatty matters into soaps made clear by the labours of Chevreul, from whose researches it results that the essential chemical change is one belonging to the class known as "single decomposition."* When vinegar is poured upon natron, not only is a gas expelled, differing from ordinary atmospheric air in that it extinguishes a lighted candle, but further, the sour taste of the vinegar and the acrid taste of the natron are both lost, and instead of these two dissimilar bodies, one substance only results (certain due proportions being observed between the vinegar and the natron); so that the chemical change may be written thus:—

$$\left\{\begin{matrix}\text{Carbonic acid gas}\\ \text{Soda}\end{matrix}\right\} + \text{Vinegar} = \left\{\begin{matrix}\text{Vinegar}\\ \text{Soda}\end{matrix}\right\}$$
$$+ \text{ Carbonic acid gas.}$$

the carbonic acid gas being displaced from combination with the constituent soda contained in natron by the acid of the vinegar. Each of the compounds, natron (or carbonic acid combined with soda) and the resulting "neutral" body (vinegar or acetic acid combined with soda, otherwise termed acetate of soda) belongs to the class of substances termed by chemists *salts*;† and soaps are substances belonging to the same category, their essential composition being this, that soda, or some body analogous thereto, is combined with an acid derived from an oily or fatty matter as starting point, forming a salt of the nature $\left\{\begin{matrix}\text{fatty acid}\\ \text{alkali.}\end{matrix}\right\}$

Natural oils and fats, however, are not identical with the "fatty acids" derivable from them; they are, in truth, a sub-class of salts in which fatty acids are associated not with an alkali or corresponding inorganic body analogous thereto, but with an organic material to some extent analogous to alkalies, but widely different from them in many other respects; this material is *glycerin*, so that the composition of a natural oil or fat may (at any rate in the vast majority of cases) be expressed by the symbol $\left\{\begin{matrix}\text{fatty acid}\\ \text{glycerin}\end{matrix}\right\}$ corresponding with the above written analogous symbol for soap $\left\{\begin{matrix}\text{fatty acid}\\ \text{alkali.}\end{matrix}\right\}$

The action of single decomposition taking place when soap is generated by the chemical reaction of a fat or oil (a "glyceride") upon an alkali, may then be expressed in the following form:—

$$\left\{\begin{matrix}\text{Fatty acid}\\ \text{Glycerin}\end{matrix}\right\} + \text{alkali} = \left\{\begin{matrix}\text{fatty acid}\\ \text{alkali}\end{matrix}\right\} + \text{glycerin}$$

To this change (as well as to certain other analogous ones) is applied the term *saponification*; all such reactions being perfectly parallel with the action of vinegar upon natron. Similar changes are brought about in the familiar experiment of the "lead tree" (displacement of lead in arborescent form by zinc, from acetate of lead); or when a bright steel blade is plunged into a solution of a copper salt (*e.g.*, sulphate of copper), whereby a portion of the iron is dissolved, and a corresponding amount of copper deposited on the blade; or when soda is added to the same solution; the reaction in this last case being exactly akin to the production of soap as above, save that in soapmaking the soap is generally caused to become insoluble in the water present (by addition of salt), whilst the glycerin remains dissolved therein, and in the soda and copper sulphate experiment, the salt formed by the chemical change (sulphate of soda, the correlative of the soap) remains dissolved, whilst the copper hydroxide (the correlative of the glycerin), set free as complementary product, is precipitated, or rendered insoluble, thus:—

$$\left\{\begin{matrix}\text{Acetic acid}\\ \text{Lead}\end{matrix}\right\} + \text{zinc} = \left\{\begin{matrix}\text{acetic acid}\\ \text{zinc}\end{matrix}\right\} + \text{lead.}$$

$$\left.\begin{matrix}\text{Sulphuric acid}\\ \text{Copper (as metal)}\end{matrix}\right\} + \text{iron} = \left\{\begin{matrix}\text{sulphuric acid}\\ \text{iron}\end{matrix}\right\} \begin{matrix}+\text{ copper}\\ \text{(as metal).}\end{matrix}$$

* Chemical changes may be classified into four orders:—

Synthetic ... $A + B = \left\{\begin{matrix}A\\ B\end{matrix}\right.$

Analytic ... $\left.\begin{matrix}A\\ B\end{matrix}\right\} = A + B$

Of Single Decomposition ... $\left.\begin{matrix}A\\ B\end{matrix}\right\} + C = A + \left\{\begin{matrix}C\\ B\end{matrix}\right.$

Of Double Decomposition ... $\left.\begin{matrix}A\\ B\end{matrix}\right\} + \left\{\begin{matrix}C\\ D\end{matrix}\right. = \left.\begin{matrix}A\\ D\end{matrix}\right\} + \left\{\begin{matrix}C\\ B\end{matrix}\right.$

The bracket signifying chemical union together of the constituent forms of matter, A, B, C, D.

† Because kitchen salt, or chloride of sodium (which may be conveniently regarded as compound of the alkali soda with a peculiar acid, hydrochloric acid) is one of the best known members of this class.

$$\left.\begin{array}{l}\text{Sulphuric acid}\\ \text{Copper (as}\\ \text{hydroxide)}\end{array}\right\} + \text{soda} = \left\{\begin{array}{c}\text{sulphuric acid}\\ \text{soda}\end{array}\right\} + \begin{array}{l}\text{copper}\\ \text{(as hydroxide).}\end{array}$$

The "fatty acids" thus conjoined with glycerin in natural fats and oils (generally known as "glycerides") are very numerous. The following list comprises a number of the more important of them, together with the chemical formula of the acid, and the leading fatty and oily matters in which it occurs:—

Name.	Formula.	Melting point.	Sources.
Lauric acid..........	$C_{12} H_{24} O^2$	44° C	Cocoanut oil. Laurel butter (bay fat).
Myristic acid........	$C_{14} H_{28} O_2$	54°	Nutmeg butter: to some extent in spermaceti and cocoanut oil.
Palmitic acid........	$C_{16} H_{32} O_2$	62°	Palm oil: to some extent in most animal fat.
Physetoleic acid......	$C_{16} H_{30} O_2$	30°	Sperm oil.
Hypogæic acid......		34°	Earthnut oil.
Linoleic acid........	$C_{16} H_{28} O_2$	..	Linseed oil.
Stearic acid........	$C_{18} H_{36} O_2$	69°	Tallow, lard, suet, almond oil, olive oil.
Oleic acid..........	$C_{18} H_{34} O_2$	..	
Ricinoleic acid......	$C_{18} H_{34} O_3$	..	Castor oil.
Arachidic acid......	$C_{20} H_{40} O_2$	75°	Earthnut oil.
Benic acid..........	$C_{22} H_{44} O_2$	76°	Oil of Ben.
Brassic acid........	$C_{22} H_{42} O_2$	33°—34°	Colza oil.

Although these fatty acids contained in natural oils, &c., are in many respects very unlike such acids as oil of vitriol and aquafortis, mineral acids of the stronger and more pronounced class, yet all of them have certain features in common with the mineral acids, of which the most salient are, firstly, that they possess the property of altering the colours of certain substances sensitive to such influences; and, secondly, that they combine with alkalies, destroying the acrid taste and other peculiarities of these substances. As regards their actions on colouring matters generally, acids and alkalies are ordinarily antagonistic, so that the term *antacid* is virtually a synonym for the latter class of bodies; in some instances the normal tint of a colouring matter is changed in one way by an acid, in another by an alkali, *e.g.*, litmus, normally of a purple or violet hue, becoming full blue in presence of alkali and red in presence of acid; in others the colour is unaffected by acid, but is changed by alkalies, *e.g.*, turmeric, the natural yellow of which becomes brown-red in presence of alkalies; in yet other cases alkalies produce no change in the tint whilst acids develop a different colour, *e.g.*, rosaniline, unaffected by alkalies, but turned crimson by acids. These peculiar colour changes are of special interest in connection with soaps, because they afford the means of accurately determining not only how much alkaline matter, as a whole, is present in a given specimen, but also how much of the alkali is present combined with the fatty acids as actual soap, and how much is present in other forms, *i.e.*, what is the proportion of "free alkali" present as compared with the "combined alkali." As already stated, this proportion in a toilet soap truly deserving of the name must not exceed a certain limit, the precise value of which will be more fully discussed in a subsequent lecture. As an illustration of the way in which this proportion may be quantitatively determined, it may be noticed that by making a "standard" acid solution of definite strength so that a given volume of it (say 1 cubic centimetre) will exactly neutralise a known amount of alkali (say for example 1 centigramme of soda—Na_2O), the total alkali present in a given sample of soap can be determined by dissolving a weighed quantity (say 10 grammes) in water, adding a measured quantity of the standard acid more than sufficient to neutralise all the alkali in the soap (say 100 cubic centimetres), boiling or thoroughly agitating to decompose all the soap and cause the fatty acids to separate from the aqueous liquid, and then testing

the aqueous liquid with an alterable colouring matter as "indicator," and a corresponding "standard" alkaline solution, so as to find out how much of the acid failed to become neutralised by the alkali in the soap. If 25 cubic centimetres of acid remained unneutralised, 75 were neutralised, representing 75 centigrammes of soda, or (relatively to 10 grammes of soap) $7\frac{1}{2}$ per cent. of total alkali. After a somewhat similar fashion the free alkali can be determined, as will be more completely discussed hereafter; if the "free alkali" were found to be 5 centigrammes, then manifestly out of the total 75 centigrammes of alkali in the soap 5 were uncombined, and 70 were present combined as actual soap; so that the free alkali in such a case would represent $\frac{5}{70} = \frac{1}{14}$ of the combined alkali, a proportion far too large for a high-class toilet soap, although much below that subsisting in many British made soaps, even of the more costly kinds.

A soap, in the widest sense of the term, implies a compound of a fatty acid with an alkali, or other metallic derivative capable of playing the part of an alkali, glycerides not being classed as soaps, for the reason that glycerin, although capable to a certain extent of playing the part of an alkali, is neither a metallic derivative nor an alkali itself. Soaps where the metallic constituent is derived from lime, lead, iron, and such like substances—although very important compounds in reference to certain special manufactures and trades (*e.g.*, in the preparation of hard fatty acids for candle-making, and in the manufacture of plasters and other articles used in pharmacy)—are not employed intentionally in the manufacture of toilet soaps; and although such compounds are unavoidably formed to minute extents in the ordinary processes of soap-boiling (owing to presence of lime in the water used, and iron rust from the vessels employed, and such like causes), and although they present many points of interest to the scientific chemist, yet their discussion on the present occasion is somewhat foreign to the matter in hand, which essentially deals with the preparation, for purposes of personal ablution, of choice varieties of substances, substantially consisting of compounds of fatty acids, derived from certain selected sources, with alkalies, and more especially with the alkali soda.

Materials Employed in Soap-making.

Besides the fatty and oily matters above mentioned as examples, a large number of other analogous substances, derived not only from natural sources, but from various waste products, are employed in the manufacture of soaps of different qualities. As regards vegetable sources, it may be noticed that comparatively few products used as food by human beings or the brute creation are entirely destitute of substances of the nature of oils as constituents; such substances as seeds and nuts (*e.g.*, wheat and oats, rice and linseed, walnuts, chestnuts, hazel nuts, and cocoanuts), more especially, may be mentioned as more or less markedly oleiferous. Those substances which contain comparatively large amounts of oil usually yield it by simple pressure, or "expression," as, for example, olives, cotton seed, and linseed; others, such as rice, containing too small per-centages of oily matters to yield them in quantity by mechanical agencies only, can yet be shown to be capable of yielding them by treatment with appropriate solvents, capable of dissolving out the oily matter and leaving the vegetable tissues, starchy matters, &c., undissolved. This method of treatment is often used in combination with pressure, the majority of the oil being expressed, and the "marc" or residue left being then treated with solvents (such as benzene or bisulphide of carbon) for the purpose of gaining the remainder.

Animal tissues are more usually "rendered," *i.e.*, heated either alone, or in contact with water, so that the fatty matters may be rendered fluid, and (being lighter than water) may be skimmed off from the top; sometimes chemical agents are also employed for the purpose of decomposing the tissues in which the fat is embodied. Processes of this kind often result in the evolution of the most abominable stenches from the melting pans, due to the decomposition of nitrogenous animal matter by the heat or the chemicals employed; in fact, it is chiefly the performance of this kind of operation which has gained for soaperies their unenviable reputation as sources of malodorous emanations. Even in the comparatively simple processes of purifying crude tallow by fusion, &c., vapours are usually evolved of so unpleasant a nature as to demand, in most localities, their destruction by passing through a fire or other deodorising agent, instead of being allowed to pass into the atmosphere; whilst the recovery of grease from bones, tannery refuse, hide clippings, intestines, defunct horses, dead cats and dogs*

* This branch of industry appears to be less cultivated in London than in Paris, to judge from the floating *débris* to be

fished up from ponds and rivers, and similar more or less decomposed animal sources, is often still more offensive, as may readily be imagined.

Various manufacturing operations (*e.g.*, textile fabrics industries) demand the use of large quantities of soap for cleansing operations; greasy matters from the waste wash water of such establishments are now-a-days often regained in large quantities, and used over again. Rags and cotton-waste, employed for cleaning machinery, &c., are often subjected to treatment with solvents for the purpose of extracting the oily matters with which they become saturated, the cotton being then washed and used over again; this cotton-waste grease recovery is quite a trade of itself in some localities where machinery is largely used. Of late years the use of hydrocarbon lubricants (from petroleum and paraffin, or shale oils, &c.,) has greatly interfered with the value of the grease thus recovered, these materials being incapable of forming soaps.

In connection with all such products recovered from waste materials (and even to a slight extent the last portions of oil obtained from olive marcs and analogous vegetable sources by means of certain solvents) it is to be noticed that, as a general rule, the nature of the materials from which the greases are extracted is such as to cause the fatty matters ultimately obtained to be more or less coloured and malodorous; and even after the employment of deodorising chemical agents, an unpleasantly smelling product is apt to be developed during the process of treatment with alkali to form soap; in consequence, these instances are mostly incapable of use for the finer varieties of toilet soaps; but they are pretty largely employed for the coarser kinds of scouring soaps which, as already stated, are to a great extent identical with some of the lower grades of tablets sold for the purpose of personal ablution, although they really bear to true toilet soaps about the same relationship that the coarsest sour peasant's rye bread does to the finest triumphs of the bakers craft.

As regards the sources from which alkalies are derived, it may be noticed that the oldest sources of natron or soda (efflorescences from certain soils, and the saline matters left on the evaporation of the water of certain lakes) are no longer available commercially, the ashes of certain maritime plants having long ago superseded them, and having been themselves disused in favour of chemical processes whereby rock salt is transformed into soda. *Kelp*, the residue left on incineration of seaweed, and *Barilla*, the similar ash of "salsoda," and other analogous plants, were for a long time the chief sources of soda, thus leading to the use of the term "marine alkali," as applied to this substance; but, during the last century or so, the production of soda from these sources has gradually declined, rock salt (or other form of culinary salt derived from brine springs, sea water, &c.) being converted into alkali by means of a series of processes essentially consisting of treatment with sulphuric acid, and heating the resulting "salt-cake" with small coal and chalk or limestone, finally separating the soluble alkali from insoluble calcareous matter, &c., by means of water. Of late years a simpler method (the "ammonia process") has superseded this one to a large extent, the essential feature in this system being the treatment of salt in watery solution with ammonia and carbonic acid gas under pressure.

Somewhat similar remarks apply to potash, the "vegetable alkali" of the alchemists. For a long period this substance was obtained in a more or less impure form by treating the ashes of burnt wood, &c., with water, and evaporating down the clarified solution obtained, thus obtaining "potashes" (*query*, ashes treated with water in a pot?) which, when refined, gave the purer and whiter material, "pearlash;" but latterly large deposits of a mineral analogous to rock salt, but containing the metal potassium instead of sodium, have been largely worked into the alkali potash by a method substantially the same in principle as the salt-cake (or "Leblanc") process used in the soda manufacture. Some amount of

seen in the Thames whenever one takes a water excursion thereon. In the French capital, the manufacture of grease and manure from the Seine flotsam and jetsam (and analogous household refuse, &c.), has for years been a source of profitable manufacture. On the other hand, it may be noticed that the proverbial expression concerning "making butter from Thames mud" owes its origin to a somewhat analogous mode of utilisation of waste impure grease derived from still less attractive sources. Much of the fatty matter used as food in large towns passes undigested through the bodies of the consumers; and, in consequence, films of greasy matter often float up to the surface of the water in the still reaches of the streams into which the town sewers discharge; this grease is sometimes collected by the simple device of letting bunches of grass or other floating masses, fixed to a line, remain in the water for a long time, so as to become coated with the slimy, fatty matters brought in contact with them by the gentle motion of the water; but it is doubtful whether grease thus obtained is susceptible of being sufficiently purified to fit it for sale as an edible substance, such as butterine, without enhancing its cost too much to render its use for this purpose profitable, although, after some purification, it is quite available for making coarse grades of soap.

potash also is now obtained by the calcination of "suint," or the greasy matters washed out of raw wool before spinning and weaving into cloth. This substance is, in fact, the inspissated perspiration of the sheep, and is remarkable in that whilst it largely consists of a kind of natural soap, the alkaline matter present in this soap is almost wholly potash. soda being contained to only comparatively small extent. It may be noticed that in the woollen trade the use of potash soaps instead of soda soaps for cleansing the fabrics is often essential, as the soaps made from the latter alkali are sometimes apt to damage the material, by deteriorating its finish in a way not so noticeable when potash soaps are employed.

It is to be remarked in this connection, that potash soaps are usually considerably softer in consistency than soda soaps made from the same materials, more especially when certain "fish oils" or "drying oils" are largely used in the manufacture; accordingly, soaps are in practice divided into two classes, viz., soft soaps, which mainly contain potash, and hard soaps, chiefly containing soda as constituent alkali. The great majority of toilet soaps belong to the latter division; a few toilet creams and shaving soap pastes, &c., however, fall into the former class.

Ammonia is but little employed as a constituent of soap proper as used for toilet purposes, although various processes have been patented involving the intermixture of ammonia with potash or soda soaps, for the purpose of increasing detergence, or of obtaining other real or supposed advantages. The chief sources of ammonia employed industrially are the liquors (mixed with tar) obtained by the action of heat upon coal, shale, bones, and other allied organic matters; and more especially the "gas liquor" resulting from the distillation of coal in ordinary gasmaking. From such liquors pure solution of ammonia, or "spirit of hartshorn," is obtained by the use of appropriate purification methods; when brought into contact with the various fatty acids in a just molten condition, and well incorporated therewith by mechanical agitation, solution of ammonia combines with the acids forming "ammonia soaps" of perfectly definite character, but considerably more prone to decomposition than the soaps of the fixed, alkalies potash and soda. In presence of a slight excess of ammonia, they usually dissolve completely in cold water, forming solutions that froth and lather precisely as ordinary soda soaps; but on boiling the solution ammonia is given off, and a residue of fatty acids combined with little or no ammonia is left.* The same result is brought about more slowly at ordinary temperatures. When an ammonia soap is allowed to stand under a bell-jar, along with a dish of sulphuric acid (to absorb water and ammonia given off), ammonia is rapidly lost, until the amount left equals one-half that chemically equivalent to the soda present in neutral soda soap from the same fatty acid; the "diacid salt" thus obtained usually loses ammonia on further standing, but far less rapidly than the original salts; the diacid ammonia salts of stearic and lauric acids (the leading constituents of tallow and cocoa-oil respectively) appear to be considerably less unstable under these conditions than those of oleic and ricinoleic acids (from olive and castor oils respectively).

Causticising of Alkalies.

One important point in connection with the alkalies used in soap-making must not be lost sight of, viz., that fatty matters are not so readily acted upon by these substances when they are in the same chemical condition as in natural natron and borith (or wood ashes), as they are when these "mild," or "carbonated" alkalies have been subjected to an action which renders them more "quick," or "caustic;" in the former case, the saponification takes place slowly, and often only imperfectly, even after long continued boiling; whilst in the latter, the conversion into soap and glycerin is much more rapid. As we have seen, when vinegar is poured upon natron, a vigorous effervescence takes place, due to the displacement of carbonic acid gas by the acetic acid of the vinegar. Now, although carbonic acid is a very weak acid, it is, nevertheless, strong enough to hinder materially the action of carbonated alkalies upon fatty matters, so as to form soap and glycerin; in many cases the reaction will not take place at all (at least for practical purposes), unless a high temperature in a pressure boiler, or other analogous apparatus, be employed. Accordingly, it is usually necessary to remove the carbonic acid from the alkali before using it

* It is noticeable in this connection that both potash and soda soaps are affected by hot water in a somewhat analogous fashion, the neutral salts breaking up into free alkali and a compound of fatty acids with less alkali than is requisite to form a neutral soap; this chemical decomposition effected by water, or *hydrolysis* as it may be conveniently termed, is of the utmost practical importance as regards the detergent properties of soap, and will be more fully discussed in a future lecture.

for preparing the soap, which operation is spoken of as "causticising," or rendering "quick," the operation being, in point of fact, chemically of the same nature as that in virtue of which limestone is converted into quicklime, only differing in the way in which the carbonic acid is withdrawn; in the case of burning limestone into quicklime, the application of heat alone causes the limestone to break up into two constituents, viz., carbonic acid gas, which escapes with the products of combustion used to generate the requisite heat in the kiln, and quicklime, which remains behind; the chemical change being of the nature known as "analytic" (*i.e.*, change of decomposition, or breaking up of complex matter into more simple forms), and expressible by the following scheme:—

$$\left.\begin{array}{r}\text{Carbonic acid gas con-}\\ \text{joined with quicklime}\end{array}\right\} = \left\{\begin{array}{l}\text{carbonic acid gas}\\ \text{in the free state}\end{array}\right\} + \left\{\begin{array}{l}\text{quicklime in}\\ \text{the free state.}\end{array}\right.$$

In the case of carbonate of soda or of potash, the carbonic acid cannot be conveniently withdrawn in this way; but by dissolving the carbonated or "mild" alkali in water, and then boiling up with quicklime, the carbonic acid is taken away from the alkali by the lime, reproducing the same chemical compound of lime and carbonic acid as constituted the original limestone before burning, and setting free the true or "caustic" alkali in accordance with the following scheme:—

$$\left.\begin{array}{l}\text{Soda (or potash) con-}\\ \text{joined with carbonic}\\ \text{acid.}\end{array}\right\} + \text{Quicklime} = \left\{\begin{array}{c}\text{Quicklime conjoined with}\\ \text{carbonic acid.}\end{array}\right\} + \left\{\begin{array}{l}\text{Soda (or potash)}\\ \text{in the free}\\ \text{state.}\end{array}\right.$$

This property of quicklime, of converting "mild" alkalies into "caustic" or "quick" alkalies, has been known for a long period, although the true explanation of the action belongs to the beginning of the era of modern chemistry; of necessity it follows that if the caustic alkali differs from the mild alkali in not containing carbonic acid associated, no effervescence due to the escape of this gas can ensue on pouring either vinegar or any other stronger acid on the caustic alkali, or into the solution thereof. This non-escape of gas is, in point of fact, utilised as a practical test of the efficiency with which the causticising process has been carried out, the boiling of the carbonated alkali with quicklime being continued until a sample of the clear liquor (after the lime used has subsided) no longer gives off bubbles of gas on treatment with excess of a mineral acid, the causticised alkaline liquor or "ley" (otherwise spelt "lye") being only then in a fit condition for preparing soap by boiling with fatty matters.

It is somewhat remarkable that quicklime will not thoroughly causticise alkaline carbonates, such as natron, if the solution be too concentrated; in order to produce complete withdrawal of the carbonic acid from the alkali, the liquid must not be more rich in soda than corresponds with about the sp. gr. 1·10 to 1·11. Formerly, soapmakers mostly bought artificial natron (soda ash) from the alkali makers and causticised it themselves; but of late years alkali makers have largely manufactured caustic soda for soaperies, &c., in the solid form, by evaporating down the causticised soda liquor, so as to render it unnecessary to carry out this part of the process in the soap works, the solid caustic being simply dissolved in water and used as required.

Classification and General Chemical Characters of Soap-making Processes.

The processes in actual use for the manufacture of soap on the large scale are tolerably numerous as regards the number of modifications in general detail rendered necessary or convenient in certain cases; but as regards their general principles they may be conveniently ranked in four leading classes or groups, viz.:—

Group I.—Processes in which fatty acids (or fatty and resinous acids) in the free state are directly neutralised with alkalies (carbonated or caustic) so as to form soaps necessarily devoid of glycerin as a primary constituent.

Group II.—Processes in which the fatty glycerides are treated with alkalies in such a fashion as to saponify them, forming soap and setting free glycerin, the arrangements being such that these two complementary products are not separated from one another, but remain permanently intermixed.

Group III.—Processes in which fatty gly-

cerides are saponified by alkalies in such a way that the soap and glycerin formed are separated from one another during manufacture so as ultimately to produce soaps devoid of glycerin as an intermixed constituent.

Group IV.—Processes virtually consisting of combinations of methods of some or all of the preceding types.

Besides these leading methods, however, there are numerous subsidiary processes, through which soaps made in accordance with one or more of these methods are subsequently put, either separately or jointly, for the purpose of finally obtaining improved finished products in the form of cakes or tablets for toilet use.

The processes of the first class are comparatively little used in the manufacture of toilet soaps, especially those of superior kinds. In the manufacture of hard candles, various methods are in use for converting natural oils and fats into free fatty acids, with formation of glycerin (either obtained as such, or more or less destroyed by secondary reactions in the process). The mixed fatty acids thus obtained yield by pressure a fluid portion (chiefly consisting of oleic acid), and a hard, far less fusible solid mass (mainly stearic and palmitic acids), the latter being the substance required for candle-making.* Amongst the various applications of oleic acid thus obtained, one of the leading ones is the conversion into soap by direct saturation with alkali, the chemical change being then a synthetic change, or one of direct union, the converse of the analytic change (or one of decomposition or breaking up) taking place during the conversion of limestone into quicklime, and being typified by the following scheme:—

$$\left.\begin{matrix}\text{Soda}\\\text{(or}\\\text{potash).}\end{matrix}\right\} + \text{Oleic acid} = \left\{\begin{matrix}\text{Oleic acid conjoined}\\\text{with soda}\\\text{(or potash).}\end{matrix}\right.$$

The crude oleic acid obtained in the candle factory is generally more or less strongly coloured brown, and the soaps made from it often share this peculiarity; as a rule, they are rather of the household or scouring class, than of the more refined and superior toilet class; but by proper treatment, the oleic acid of the candle maker can be made to yield (especially when purified, and the neutralised mass admixed with soaps made from other kinds of material) a very fair kind of toilet soap.

When ordinary resin (crude or refined) is boiled with alkaline solutions, a substance is similarly formed by the direct combination of the resinous acids present with the alkali, closely akin to some kinds of soap; this product is somewhat largely employed as a constituent of certain kinds of mixed soaps (resin soaps), the preparation of which, as a whole, rather belongs to the fourth class of processes than to the first.

Processes of the second class may conveniently be subdivided into three groups, viz.:—

a. Where the fatty matter to be treated and the alkali (previously causticised) are incorporated together, at temperatures lower than the ordinary boiling heat, and allowed to remain in contact until the saponification is complete, without concentration by boiling down. Such processes are usually known as "cold" processes, not that the action is actually carried out in the cold, but because the temperature is relatively low throughout; the alkaline leys are ordinarily used of considerable strength, so that there is not so great a quantity of water present as to prevent the resulting product setting firm on cooling and standing. Processes of this kind are largely used in toilet soap manufacture.

b. Where the fatty matters and alkaline leys are boiled together in vessels, under ordinary atmospheric pressure, a certain amount of concentration by evaporation of water taking place during the process. This method is adopted in the manufacture of soft soaps (essentially potash soaps, but often containing a certain amount of soda); and in certain classes of hard soaps, especially those of the marine kind (mainly made from cocoanut oil, the soda soap of which will lather with sea water, which most other soaps will not do).

c. Where the fatty matters and alkaline leys are made to react upon one another, under increased pressure, and at a temperature above that of the boiling heat under ordinary pressure. Methods of this class are rarely, if ever, used for the production of the choicer kinds of toilet soaps, as the increased heat renders the product more liable to possess an odour objectionable for articles intended to be delicately perfumed.

* During the last few years a process has been patented (but as yet apparently not extensively used) for the preparation of free fatty acids, either for soap-making by direct saturation, or for separation into solid and fluid acids by pressure, which depends on the circumstance that, at a moderately high temperature—obtained in a pressure apparatus—and in presence of aqueous ammonia, oils and fats are saponified, forming ammonia soaps and glycerin, the former being to some extent permanent under pressure, but readily breaking up into free ammonia and free fatty acids when heated under the ordinary pressure.

In all three of these methods the amount of fatty matter and alkali must be carefully proportioned to each other, the amount of alkali relatively to the fatty matter varying with the nature of the acids, of which the fatty matter contains the glycerides, and being the greater the lower the chemical equivalent of the fatty acids present. If too little alkali be added, the resultant soap contains unsaponified fat, and is greasy; if too much, it contains more or less "free alkali," and is consequently rendered of inferior quality for toilet use.

Processes of the third class constitute those by which the majority of the ordinary scouring and household soaps in everyday use are prepared. According to the scale on which they are carried out, and the nature of the materials employed, the manipulation and mode of treatment is subject to considerable variation; but, as a whole, these processes may be said to possess in common the distinctive feature that the fatty matters serving as basis are boiled with comparatively weak alkaline solutions until saponification is completed, or nearly so, when the glycerin and soap are separated by the addition of salt, which, dissolving in the water, forms a brine in which the glycerin is soluble and the soap insoluble, so that the latter separates from the mass as a soft molten paste, which is put through various purifying and finishing stages before casting in moulds, in which it solidifies into blocks which are subsequently cut up into bars, &c.

Amongst processes of the fourth or mixed class may be mentioned more especially the methods generally used for the preparations of "yellow" or resin soaps, in which a soap prepared by the third or boiling process is admixed with another prepared by saturating resin with alkaline ley, and the mixture then purified and cast into blocks; or in which a partially boiled soap, containing excess of caustic alkaline ley, is treated with resin directly so as to form the resinous soap in the body of the mass, the final product being purified, &c., as before. In a similar fashion various other classes of soap are occasionally prepared by intermixing with a boiled soap a quantity of caustic alkali, and then adding a glyceride, so as to produce a sort of combination of boiled soap with cold process soap; or by other analogous modes of treatment. As a rule, however, these mixed soaps are prepared by making each kind separately, and then intermixing them thoroughly, either whilst freshly made and before cooling, or subsequently by remelting them together and so blending them. This process of remelting is one of the most extensively used of the subsequent processes through which soaps manufactured in one or other of the above ways are put in order to "refine them," and improve their quality. In many cases small quantities of additional constituents are added during the remelting, for the purpose of giving distinctive qualities; in others the constituent soaps are simply blended, tinted, and finally perfumed by addition of fragrant oils, &c., at as late a period as possible consistent with due intermixture to diminish the injurious action of prolonged heating upon scents. A mechanical mode of blending without heating, known as "milling," has of late years come largely into use, on account of the possibility of using more delicate perfumes in this way, and other advantages.

In the strict sense of the term, "refining" should indicate putting the original stock soaps through processes which will render the resulting mass more pure and suitable for application to the skin. Certain processes of the kind are actually in use, the object of which is to diminish the amount of free alkali present, either by mechanical means, or by chemical modes of treatment finally resulting in the same effect, or by clarifying and purifying the mass by solution in spirit. These processes will be discussed more fully in a subsequent lecture. It, unfortunately, happens, however, that with a large portion of the toilet soaps sent into the market, not only are such processes not adopted, but on the contrary, methods of treating the soap are largely used *which add to the alkalinity*, thereby greatly impairing its value from the point of view of suitability for habitual use by persons possessing tender and sensitive skins; the reason for the adoption of these methods being either for the sake of improving the grain or texture of the mass (an improvement dearly purchased at the expense of deterioration in quality), or of communicating greater hardness and durability. The first result is usually sought to be effected by "pearlashing, *i.e.*, adding to the melted mass a proportion of pearlash (or refined potashes), which brings about a remarkable chemical change, viz., the transformation of soda soap into potash soap, with simultaneous production of carbonate of soda instead of carbonate of potash, and the admixture of these products with the original mass causes a marked alteration in its

physical character. The second result is often attained by similarly incorporating into the mass "soda crystals," which addition causes (especially with certain kinds of fatty acid soaps) a notable stiffening and hardening of the whole, so that a firm mass results, even if a moderately large amount of water be present. The same effect can also be produced by the employment of certain neutral salts, *e.g.*, sulphate of soda and common salt.

Concerning the use of these materials in the production, at a cheaper rate, of ordinary household soaps, which have been increased in bulk by more or less copious addition of water and "filling," there is much to be said on both sides of the question; but no two opinions are possible in reference to toilet soaps. Any considerable amount of even a neutral compound (like common salt) is objectionable in a soap intended to be used by persons with sensitive skins and delicate complexions; and *a fortiori* alkaline salts, such as soda crystals, are substances the presence of which should be carefully guarded against in such products. Experience of the deleterious action of highly alkaline British soaps leads many to the use, by preference, of various brands of Continental origin, in which this fault is avoided. These "skin soaps," as they may be termed, are often notably more costly than ordinary British makes (from one to several francs per tablet being a usual range of price); but there appears to be no reason, beyond insular prejudice, why equally good articles should not be prepared at home at far lower prices; and recently the British soap trade has shown signs of becoming alive to the fact. As matters stand, however, at the present moment, it by no means follows that a high-priced British made soap is an article to be recommended from the point of view of its quality *as a soap*, although it may be made by a perfumer of the highest reputation in this particular line, and may be well worthy of that reputation when viewed simply *as an article of perfumery*.

On the other hand, it may be remarked that there are in the market a large number of articles sold at low prices (penny and twopenny tablets) under the name of "toilet soaps," the qualities of which, as a rule, hardly justify the application of this term to them. These soaps are mostly ordinary boiled unrefined household soaps (often at best only of second-rate quality as regards the fatty matter used as basis), more or less tinted and scented with cheap essential oils, and more especially with mirbane or artificial oil of almonds (nitrobenzene), so as to disguise the faint or unpleasant odour derived from coarse fatty matters. The better substances of this class have usually been more or less refined, and are accordingly not remarkably alkaline, and consist either of ordinary "yellow" or resin soaps, or of analogous "fitted" nearly neutral household soaps, worked into tablet form instead of bars; and of them it may be said that at least they are better value for the money than are many articles sold at much higher prices. But of the inferior kinds of tablets of this description but little can be said in praise, or even in mitigation of condemnation. Not only as a rule are they made without any attempt at refining from cheap, and often rank, fatty matters, but further, in many instances, they are excessively "watered," saline matters (notably sulphate and carbonate of soda) being copiously added to harden and "close up" the mass. Sometimes they are made of little but cocoanut oil, with a great excess of caustic alkali, and sometimes an admixture of sugar (this variety, however, is more frequently made abroad than in England); they then possess the doubtful merit of rendering a razor almost superfluous when used as shaving soaps, the alkalinity being almost sufficient to destroy the tenacity of hair without any cutting instrument being required; unfortunately, the epidermis is apt to be equally causticised, to the great discomfort of the user. Soaps that have been heavily watered are always apt to get out of shape by exposure to air, through shrinkage in drying; and often to become simultaneously covered with a white saline efflorescence, caused firstly by the "sweating" out of liquid from the interior, and, secondly, by the evaporation of the water, leaving behind a more or less crystallised mass of the salts used for hardening, which were dissolved in the liquid. When any noticeable efflorescence is produced on a tablet on keeping, there is at least a high degree of probability that an undue amount of alkalinity is possessed by the soap, together with the certainty of the presence of saline matter in quantity not likely to be beneficial to tender skins; whilst it is not at all unlikely that the same desire for cheapening that has led to undue sophistication with water and salts, has also caused the employment of the cheapest and coarsest fatty matters; wherefore *all such soaps should be studiously avoided* by persons at all subject to skin irritation of any kind.

It may be noticed in passing, that the prac-

tice of "watering" household soaps, and "closing up," by addition of saline matters, is now-a-days carried out to such an extent, and so ingeniously as to be almost a fine art, so that there is a proverbial expression concerning this class of trade, referring to "making water stand upright" as a main source of profit; and that as regards the amount of foreign matters that can thus be incorporated (especially when cocoanut oil is freely used as part of the fatty matter, this substance lending itself to the practice better than almost any other) it is by no means uncommon to find on analysis less than one-sixth (16·7 per cent.) to be actual soap, the balance being water with saline matter added, to close or harden the soap; so that the soap trade in these matters completely leaves behind the most ambitious milkman that ever resorted to the "cow with the iron tail" to increase his stock. On the other hand, it is to be said that the general public will persist in demanding soaps (and most other goods) at prices quite inconsistent with a high per-centage of genuine ingredients, and that the heavily watered and highly salted kinds of soap possess at least certain good qualities to a greater extent than might at first sight be expected from their composition; thus the addition of a considerable quantity of sulphate of soda solution, crutched into the soap just before solidifying, not only enables the price to be reduced so as to meet the demand, but it also actually hardens the soap (partly from the crystallising of the saline solution, partly from a peculiar physical action on the soap), and thus prevents it from wasting as rapidly in use as it would do were water only added. Again, the addition of a large amount of silicate of soda, aluminate of soda, carbonate of soda, and other alkaline compounds, not only produces this hardening effect to a greater or lesser extent, but also adds to the detergent power of the soap; so that for household cleansing purposes, these "doctored" soaps are not really as uneconomical and objectionable as they might be supposed at first sight to be, although for toilet purposes they are of course utterly inadmissible.

In connection with the general chemistry of the manufacture of soaps, and more especially with the processes involving "cutting" or separation of more or less perfectly formed soap from its solution in water by addition of saline matters, and especially of common salt, some curious points relating to the chemical and physical principles involved in the action may be here adverted to. It has long been known that if a potash soap dissolved in water be "cut" with common salt (chloride of sodium), the two alkalies present, potash and soda, and the two acids, hydrochloric acid and the fatty acids of the soap, change places in virtue of a class of change known as "double decomposition," analogous to that ensuing when the same common salt (soda conjoined with hydrochloric acid) is brought into contact with solution of nitrate of silver (silver conjoined with nitric acid). The two kinds of chemical change may be expressed by the following schemes, the potash soap being considered as consisting of potash combined with stearic acid:—

$$\left\{\begin{matrix}\text{Stearic acid con-}\\\text{joined with pot-}\\\text{ash.}\end{matrix}\right\} + \left\{\begin{matrix}\text{Hydrochloric acid}\\\text{conjoined with}\\\text{soda.}\end{matrix}\right\} = \left\{\begin{matrix}\text{Stearic acid con-}\\\text{joined with}\\\text{soda.}\end{matrix}\right\} + \left\{\begin{matrix}\text{Hydrochloric acid}\\\text{conjoined with}\\\text{potash.}\end{matrix}\right\}$$

$$\left\{\begin{matrix}\text{Nitric acid con-}\\\text{joined with}\\\text{silver.}\end{matrix}\right\} + \left\{\begin{matrix}\text{Hydrochloric acid}\\\text{conjoined with}\\\text{soda.}\end{matrix}\right\} = \left\{\begin{matrix}\text{Nitric acid con-}\\\text{joined with}\\\text{soda.}\end{matrix}\right\} + \left\{\begin{matrix}\text{Hydrochloric acid}\\\text{conjoined with}\\\text{silver.}\end{matrix}\right\}$$

In conseqence of this change, it is impossible to manufacture soft soaps by processes involving salting out with common salt, because the addition of this substance would convert the soft potash soap into hard soda soap, potassium chloride being formed as a complementary product. On the other hand, this mutual decomposition is available for the manufacture of hard soda soaps under circumstances where caustic soda is less readily obtainable than potashes, *e.g.*, where wood ashes are obtainable readily in districts a long way from commercial centres where soda ash and caustic soda can be bought;* and accordingly in certain districts it has long been the practice to saponify grease and fatty matters with a potash lye prepared from wood ashes and lime, and then to add salt for the purpose of obtaining a comparatively hard soda soap. At the present day, however, this reaction is comparatively but little used, at any rate in this country; it is noticeable that the soda

* In all probability hard soaps were first manufactured in this way, the use of wood ashes and fatty matters for making potash soaps of a crude character being, as above stated, the earliest traceable kind of soap manufacture.

soap thus formed always retains a certain amount of admixture of potash soap, which communicates to the whole mass certain desirable properties as regards grain and texture, &c.; accordingly, it is now frequently the practice to produce the same result in other ways for the purpose of securing these advantages, the most usual methods being either to employ a mixture of caustic soda and caustic potash to act on the fatty matters in the first instance, or to blend together (by remelting or otherwise) potash and soda soaps in due proportions; or to add a certain quantity of pearlash (purified potashes) to soda soap, which last process has, as already stated, the great disadvantage of increasing the alkalinity of the soap. The *rationale* of this last process appears to be (in accordance with the result of investigations made in my own laboratory, with the co-operation of Mr. C. Thompson) the formation of potash soap and carbonate of soda in accordance with the following scheme:—

$$\left\{\begin{matrix}\text{Fatty acids conjoined}\\ \text{with soda}\end{matrix}\right\} + \left\{\begin{matrix}\text{Carbonic acid conjoined}\\ \text{with potash}\end{matrix}\right\} = \left\{\begin{matrix}\text{Fatty acids conjoined}\\ \text{with potash}\end{matrix}\right\} + \left\{\begin{matrix}\text{Carbonic acid conjoined}\\ \text{with soda}\end{matrix}\right\}$$

This reaction is of interest, inasmuch as it exhibits the inverse transformation of that occurring when common salt is added to a potash soap, potash being displaced from combination with fatty acids by soda in the one case, and *vice versâ* in the other. Both changes, in point of fact, occur in accordance with a general rule applying in such cases, viz., that when potash and soda are simultaneously present in contact with two acids jointly equivalent to the sum of the two alkalies, there is a marked tendency for the potash to unite with the stronger acid, and for the soda to unite with the weaker one; hydrochloric acid being a stronger acid than the ordinary fatty acids, whilst carbonic acid is weaker than these, it results that if fatty acids and hydrochloric acid constitute the pair, the potash unites by preference with the hydrochloric acid, and the soda with the fatty acids, forming soda soap; whilst if fatty acids and carbonic acid constitute the pair, the potash will unite by preference with the fatty acids forming potash soap, leaving the soda to combine with the carbonic acid.*

It is to be noticed, in connection with this general rule, that we find that, under certain conditions, changes may be brought about which are apparently in opposition to it; in point of fact, the two acids and the two bases always so associate themselves as to give rise to *four* salts, viz., those obtainable by the combination of each acid with each base; and by varying the relative masses of the acids and bases in certain ways, one pair of salts can be made to predominate over the complementary pair under one set of conditions, and *vice versâ* under other conditions. For example, we find that if a soda soap be dissolved in water, and a large quantity of potassium chloride added to the solution, it is possible to convert considerably more than half of the soda soap into potash soap, with formation of the corresponding quantity of sodium chloride; out of the four compounds, (1) potash soap, (2) soda soap, (3) potassium chloride, and (4) sodium chloride, under these conditions, (1) and (4) are formed to a larger extent than (2) and (3), so far as the fatty acids and soda are concerned; whilst, if a potash soap be similarly treated with sodium chloride, the same four salts will result, only now (2) and (3) will be formed to a greater extent than (1) and (4), so far as the fatty acids and potash are concerned; the difference in the two cases being essentially due to the fact that, in the first instance, a relatively large mass in excess of (3) is present, and in the second a similar excess of (4).

In a similar way, if a potash soap be well intermixed in a molten condition with a solution of carbonate of soda, and if, in a parallel experiment, a soda soap be intermixed with carbonate of potash, in each case four compounds will result—viz., (1) potash soap, (2) soda soap, (3) carbonate of potash, and (4) carbonate of soda; the relative proportions in which the two alkalies are associated with fatty acids depending on the mass and nature of the alkaline carbonate present. In this instance, however, the displacement of potash from combination with fatty acids by soda always takes place less readily, and that of soda from combination with fatty acids by

* In the same kind of way, when nitrate of soda and carbonate of potash are brought together in solution, nitrate of potash and carbonate of soda are formed, nitric acid being a stronger acid than carbonic acid; this reaction has long been utilised as a means of manufacturing saltpetre from the cheaper nitrate of soda.

potash more readily, than is the case when alkaline chlorides are used as above instead of carbonates.

It is remarkable that when there are two alkalies present (potash and soda) in the caustic state (*i.e.*, as hydroxides) and no acid except the fatty acids of soap, there is no marked preferential combination of either alkali with the fatty acids as compared with the other. Thus we find that all the ordinary fatty acids, when treated with a mixture of caustic potash and caustic soda in equivalent proportions, and in quantity jointly equal to twice the amount capable of combining with the fatty acids, appear (according to our experiments) to form a mixture of potash and soda soaps, containing sensibly half the fatty acid in combination with the one alkali and half with the other, whilst the uncombined alkaline ley similarly contains equivalent quantities of each alkali.*

It may be added that our experiments have also been continued in the direction of the examination of ammonia soaps and salts and their reactions respectively on the salts and soaps of the fixed alkalies; with results of interest from the point of view of the study of the modes of partition and combination of pairs of acids and bases respectively when present together, and the influence thereon of circumstances. Thus it may be noticed that if an aqueous solution of an ammonia soap be prepared (by neutralising a fatty acid with a slight excess of ammonia solution and dissolving in water without the application of heat), and chloride of potassium or sodium be added thereto in quantity, chloride of ammonium is largely formed, and a soap thrown out of solution in the briny fluid which contains the great majority of the fatty acid combined with fixed alkali equivalent to the chloride of ammonia produced; but, on the other hand, if a potash or soda soap be similarly dissolved in water, and chloride of ammonium in large quantity be added to the solution, the great majority of the fatty acid goes out of combination with the fixed alkali, which becomes almost wholly transformed into chloride, whilst an ammonia soap is the complementary product first formed (usually more or less completely broken up into free ammonia and an acid ammonia soap by a secondary reaction).

* The experimental data on which these conclusions are based, and the results of various other analogous experiments, are hardly suitable for discussion on the present occasion; their description is therefore deferred until a convenient opportunity of communicating them to another society occurs.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The number of visitors to the Exhibition for the week ending Tuesday, 20th October, was 142,422. Total since the opening, 3,417,748.

MEASURES FOR IMPROVED PHYSICAL TRAINING.

By Edwin Chadwick, C.B.

(Concluded from page 1072.)

In France an important advance is being made in the half-time principle of mixed physical and mental training, and providing for earning going on with learning.

In 1867, on my presentation, by Lord Brougham, to the Institute of Paris, as successor to Archbishop Whately, at the Institute, I took for my thesis a paper on the half-time principle, that is to say, on mixed physical and mental training. I afterwards received a silver medal, moved by Woloski, for the part I had taken in the introduction of the principle for the protection of children in factories. It has since been adopted in an efficient manner in Paris, but, as I have subsequently shown, it cannot be efficiently applied, unless in a larger educational organisation than is afforded by the small communal schools.

At the recent great International Congress of nearly three thousand School Teachers, at Havre, the principle was brought forward by Mdlle. Bonnevial, who had been charged to represent the Société d'Education Intégral, or complete education of Paris, and who explained the term *travail manuel* as it was understood by the adherents of the Society. "It was not sufficient, as stated in the programme, that workshop instruction, or industrial work (*travail manuel*) should be regarded as a complement to the ordinary work of the elementary school. It must not be considered as a subsidiary part of the school curriculum, nor even be put on an equality with intellectual exercises, but it must be made the primary groundwork and basis of all instruction. All the pedagogic systems had the radical effect of commencing with abstractions, instead of commencing with the concrete. Pestalozzi and Fröbel had shown them a true way, and the proposal to make industrial work the basis of all popular instruction was a logical outcome of their principles. It was universally admitted that the education of the whole man—complete and integral education—should be the object of all teaching. It

was universally admitted that for young children the kindergarten was the true school, and the characteristic of that system was the substitution of the concrete for the abstract in the methods of instruction. The contention of the "Société d'Education Intégral" was as true of the elementary school for boys and girls up to a certain age as it was of nursery schools and infant schools. There is a time no doubt when abstractions must be introduced, but the concrete ideas must first be introduced before abstract ideas could be usefully employed, and the latter should be obvious and natural deductions from the former." Eventually the following resolution was carried by a large majority of the members of the congress:—"Section A., recognising that industrial work (*travail manuel*) ought to form an integral part of any good system of general education, because it contributes to the development of activity, observation, perception, and intuition, puts on record its desire that it should be introduced as early as possible into all elementary schools."

M. Sluys entered a protest against the excessive intellectual tasks required of pupils of the normal schools. He maintained that ten hours and even twelve hours of study were commonly demanded, and that such a demand was often injurious to the bodily health, and tired the brain beyond measure. A proposal to give a larger proportion of the time to physical exercises was then unanimously adopted.

Of the practical application of the concrete over the abstract, in teaching, an important advance appears to have been made in Sweden. A professor there observes how superior a mental exercise it is to get a boy to put a box together, and observe how the parts fit, than one of the lessons of making verbs and parts of speech and the abstractions of grammarians to fit. But in my view, the most important contribution to the principle adopted at the school teachers' congress, of the priority of the concrete over the abstract, comes from the United States, where it is applied in the most formative period of life—the early infantile stage. At the kitchen garten school, a table is provided with toy cups, spoons, saucers, and apparatus, which the children are taught to take on and off. They have also toy brooms with which they sweep the room. Every motion is to the music of the piano and the song, to their great interest and delight; they are taught to receive and to deliver messages. For the boys, there is a farm garten, and a table with a stratum of soil, over which there runs a toy plough, then a toy drill to deposit seed, and a toy reaper to remove the crop. The chief agricultural operations are also to music and to song. These concrete and visible operations are completely understood by the children, and interest them; whilst abstract dogmas are not mastered, retained, and do not influence their action. Mothers of the single-roomed or mud-hovelled cottages come and complain that their little tots of children tell them how things ought to be done, and set them to rights, much to the interest and the amusement of the father. It is to be regarded as an important object to contribute the cheerful influence to the joy of childhood in the cottage, in place of the depressing effect of any homework, in repulsive, and generally profitless abstractness.

Our committee, I expect, will be of opinion that on sanitary grounds, the compulsory attendance at school should be limited to three hours, that is to say, to bookwork exclusive of physical exercises.

The half-time principle has been well introduced in the elementary schools of Paris. At the congress it was claimed as the idea of the First Republic obtained from Rousseau. I should be glad of the acceptance there of the principle under that belief. We, however, knew nothing of it when the principle was introduced in England under the Factories Act for the regulation Act, as a means of protecting children against overwork, and of securing to them the benefits of education of which they were previously deprived. As a fact, however, the First Republic did nothing with the principle, nor was anything done with it until very recently; and the educational authorities appear to have failed to perceive that it will be inapplicable to the small communal schools of France or of any other country under such a local organisation, and that it can only be carried out with efficiency and economy by the organisation of large graded schools, and by the simplification and the reduction of the time now occupied with mental instruction.

The educational functions of the largest spending department, the Privy Council, are mixed up with functions for the prevention of cattle disease and others. There are educational functions mixed up with those for the relief of indigence, of town drainage and water supply, of roads and of other functions under the Local Government Board. Educational functions are mixed up with those of penal administration of the Home Department and Naval Department. Each of these scattered educational functions are exercised by separate central authorities, with separate local inspectorship acting on separate principles. Those of the Poor-law Board, the Home-office, and the War and Naval Departments acting mainly on the half-time principle of mixed physical and mental training which, as a principle, may be said to be unknown at the Education Department of the Privy Council. These scattered functions were, in great part, reviewed during the last session of Parliament, by a select committee of the House of Commons, which arrived at the conclusion that they should all be consolidated in one department under a minister of education. It is submitted that the proposed measure would require careful consideration for its promotion, as generally it may be made the means of collecting and applying the latest and the best experience, for largely improving the quality of the education maintained from the public funds, and of reducing its time and expense, and of augmenting the physical and the mental and the

moral force, and also the productive power of the country.

It remains to state explicitly the military services derivable from the military drill in elementary education, and to show that those services will be clear of the apprehensions expressed by the trades unionists of leading to conscription—that in fact they will contribute, to an important extent, to the great volunteer movement, which comprises a large majority of the wage classes throughout the country. They, however, combine sanitary services for a large proportion of urban population which are of considerable importance. A great number of boys, who have had the physical exercises, will, on leaving school, enter into sedentary occupations, in which the physical services are seriously reduced commonly to a quarter of what is requsite to keep the body in healthy action. Constitutional walks are of inferior effect. The bicycle or the tricycle may not be afforded, or may not be available to reach the suburban residence. In such conditions the volunteer movement, which gives to the sedentary a Saturday afternoon's exciting exercise or an outing for autumnal manœuvres, gives a valuable sanitary contribution of relief. For the relief of the youths who have left school for sedentary occupations, in which the want of exercise is soon felt, cadet corps are proposed in connection with the volunteer movement. To that movement they will give a contribution of great intelligence and ability derived from the preceding training in the infantile and juvenile stages. It was an axiom of the first Napoleon that in military organisation, whilst *physique* is as one, *morale* is as two, that is to say in intelligence and ability. The military orphan asylums, which are conducted on the half-time principle, do, in fact, in their outcome supply a large proportion of non-commissioned officers of the first class, and even some commissioned officers. The cadet corps would best supply the skill needed for wielding the new machine guns displayed in the Inventions Exhibition, which are calculated to effect such large alterations in military organisation. The tendency would be, in principle, to the augmentation in power of that great volunteer force of a quarter of a million of men, of whom the trades unionists may observe that the great majority are of the wage classes. The superiority of the quality of this force over our own barracked force, or over any conscripted and unwilling, and, therefore, inferior force, will be found to be incontestible. Our volunteers now beat the regulars in competitions as artillerists, for Lancashire volunteers certainly would not require forty shots to bring down one Zulu, or fail at long ranges, or require to be brought so close that it is impossible to miss, as has been displayed by the regulars. In any case, whilst other nations are advancing with exercise of the military drill in their elementary schools, would it be for us to stay such exercise in ours? The trade unionists may be assured, however, that with our great free volunteer movement, and with force of such high quality, they need be in no fear of any forced conscription.

TELPHERAGE.

On the 17th inst., the first line for the conveyance of goods by the electrical system invented by the late Professor Fleeming Jenkin, and entitled "Telpherage," was formally opened at Glynde, near Lewes. The system was fully described in a paper read before the Society by the inventor on May 14th, 1884, but the details have been somewhat modified since that date. The line is a double one, nearly a mile in length, and is composed of two sets of steel rods, three-quarters of an inch in diameter, supported on wooden posts of T-shape, and about 18 ft. high. The wires are supported one on either end of the cross-piece of the T, which is 8 ft. long. The carriers, or skips, as they are technically termed, are iron, trough-shaped buckets, each holding about 2 cwt., and suspended from the line by a light iron frame, at the upper end of which is a pair of grooved wheels running on the line of rods. A train is made up of ten of these skips, which are in electrical connection with each other, and with an electrical motor which is placed in the middle of the train, having five skips in front of and five behind it. At a point about midway of the length of the line is the engine-house, in which is a steam-engine which drives the dynamos. From these latter the current is led to the line, and thus to the electrical motor which moves the train. The use to which the line is put is to carry clay from a pit to the Glynde railway siding, whence it is delivered into trucks, and transported by rail to the works of the Newhaven Cement Company. At the charging end of the telpher line the skips are loaded each with about 2 cwt. of clay, the train thus carrying one ton. A labourer, by touching a key, starts the train, which travels at a speed of from four to five miles an hour along the overhead line to the Glynde Station. Arrived there another labourer upsets each skip as it passes over a railway truck, into which the clay is thus loaded. This upsetting, however, is eventually to be performed automatically by means of a lever on each skip, which will come in contact with a projecting arm as it passes over the truck.

General Notes.

EXPORTS OF WHEAT FROM INDIA TO ITALY.—During the financial year 1881-82, the total quantity of wheat exported from India was 993,176 tons, of which 17,966 were imported by Italy. In the year 1882-83, whilst the total quantity was 737,220 tons, the exports to Italy were only 8,800 tons. In 1883-84, the total exports were 1,047,824 tons, and that to Italy 22,270 tons. In 1884-85, from a total of 792,714 tons exported, Italy received 35,045 tons, by which it will be seen that the exports of wheat to that country have nearly doubled in four years.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

UNION OF INSTITUTIONS.

The following Institutions have been received into Uuion since the last announcement:—

Aldenham Institute, Goldington-crescent, N.W.
Leyton and Walthamstow Young Men's Christian Association.

Proceedings of the Society.

CANTOR LECTURES.

THE MANUFACTURE OF TOILET SOAPS.

Lecture II.—Delivered May 11, 1885.

PLANT AND APPLIANCES USED IN SOAP MANUFACTURE.

So many variations in methods of procedure, according to circumstances, are from time to time introduced, and so many differences exist in the appliances best calculated to effect a good result under these varying conditions, that an adequate description of soap-making plant in general is far beyond anything possible in the limited amount of time at our disposal; it is only practicable to attempt a hurried glance at some of the more salient features of the leading methods adopted.

As regards the methods of soap manufacture placed in the first group, according to the classification attempted in the previous lecture (*i.e.*, the methods depending on the direct neutralisation of fatty or resinous acids by alkalies), it may be noticed that whereas formerly carbonated alkalies were mainly used for the purpose of acting upon oleic acid so as to form soap, their use is at present much less frequent, because the saving in cost effected by dispensing with the process of causticising the alkali is now so small (thanks to improvements in alkali manufacture), as not to counterbalance several disadvantages attending their employment, mainly on account of the frothing brought about by the liberation of carbonic acid gas. For preparing hard oleic acid soaps by means of soda, the plant ordinarily employed consists of a steam-jacketted pan, provided with an efficient agitator, such as one consisting of two sets of vertical vanes moving in opposite directions, in such wise that the vanes of the two sets interlace in passing each other. The oleic acid is run into the pan, and heated up by admitting steam into the jacket; the alkaline ley (usually also heated) is then run in gradually with continued agitation, its strength and quantity being so regulated that the mass finally resulting after the operation is completed is not too moist to set into a compact mass on cooling, and so that, whilst the oleic acid is completely converted into oleate of soda, there should not be any considerable excess of alkali present; a sensitive tongue being usually the means of judging adopted, and a little more oleic acid or soda ley being added, according as the mass contains too much or too little caustic alkali in excess to produce the desired "bite" or "touch" when the mass is tasted.

When carbonated alkali is used, as in what is known as "Morfit's Process," the pan is usually provided with a "curb," a sort of hoop or funnel affixed temporarily to the top, to avoid overflow during the foaming up caused by the disengagement of carbonic acid, which takes place in accordance with the reaction,

$$\left.\begin{array}{c}\text{Soda conjoined}\\ \text{with}\\ \text{carbonic acid}\end{array}\right\} + \text{Oleic acid} = \left\{\begin{array}{c}\text{Soda con-}\\ \text{joined with}\\ \text{oleic acid}\end{array}\right\} + \begin{array}{c}\text{Carbonic}\\ \text{acid.}\end{array}$$

precisely similar to that ensuing when vinegar is poured upon natron, as illustrated in the preceding lecture.

Some manufacturers prefer to boil the oleic acid with weaker leys, more or less causticised, and generally containing an admixture of salt, such as the liquid obtained by causticising with quicklime commercial "48 per cent. soda ash," a product which contains about 10 per cent. of common salt (and other saline

impurities). When the soap is partially formed, it becomes more or less insoluble in the briny aqueous liquor (especially on addition of more salt), so that this latter separates on standing; this "spent ley" being then run off, more soda ley is added and the boiling continued, and so on in much the same way as that adopted in the saponification of ordinary fats and oils by processes of the third group, which will be referred to by and bye. In many cases the oleic acid is not used alone, but admixed with other various fats, &c.; sometimes an oleic resin soap is prepared by treating oleic acid and resin mixed together with caustic alkali, or by separately combining them with the alkali and mixing the products. In this case the compound of resin acids and alkali is prepared by heating together the resin and caustic alkaline ley until complete combination has taken place, the process being effected in much the same way as in the case of oleic acid directly treated with strong leys, and not salted out in any way. For effecting the intermixture a peculiar kind of agitator is often used, known as "Morfit's steam twirl," consisting of a kind of rotary paddle fixed inside the pan, and made up of a long convoluted tube, with perforations at intervals along its length. This tubular stirrer is connected, by means of a hollow spindle, with the steam boiler, so that, when desired, steam can be admitted inside of it; in this way, not only is the agitator itself always kept hot by the steam, but further continuous jets of steam are made to issue through the perforations, so that rapid heating and most effective intermixture of the contents of the pan are brought about; when resin and soda leys containing from 10·0 to 11·0 parts of anhydrous soda (Na_2O) per 100 of resin* are thus intermixed, the product is a jelly-like material consisting of the soda salts of the resinous acids, more akin in physical texture to soft potash soaps than to ordinary hard soda soaps, but capable of blending with these latter, so as to form the so-called "resin-soaps" of commerce, of which the "primrose" varieties (made from the palest "window-glass" resin) are the most esteemed.

* Resin, or colophony, mainly consists of two isomeric acids of formula $C_{20}H_{30}O_2$ (sylvic and pinic acids), so that 100 parts of either acid would correspond with 10·26 parts of Na_2O. Other analogous organic acids, or their anhydrides, have also been described (pimazic acid, abietic anhydride, &c.) as present therein. On the whole, the average combining value of the resin acids present is usually near to 295—310, corresponding with from 10·0 to 10·5 parts of anhydrous soda, Na_2O, per 100 of resin.

Another substance analogous to oleic acid is frequently employed in the same way, to form soaps by direct neutralisation with alkali, viz., the "grease" recovered from the waste soapy liquors from dyeworks, calico printing, and the like; this recovered grease is usually obtained in the form of a mixture of free fatty acids with more or less colouring matter and other impurities, being produced either by addition of sulphuric acid to the soapy fluids, whereby the soap is decomposed, and the fatty acids liberated float up to the top, or by forming a lime soap by addition of calcareous compounds, which lime soap is subsequently decomposed by a mineral acid. As a rule, this kind of grease is utterly unsuited, from its olour and disagreeable odour, for the manufacture of the better class of toilet soaps, even after as complete bleaching and deodorisation as can be effected; but it is often worked up into inferior kinds of "brown Windsor" and similar brown soaps, to which nitrobenzene or other powerful cheap scenting materials are added, for the purpose of overpowering the unpleasant odour due to the fatty matters. Much the same remarks apply to a somewhat lesser extent to oleic acid soaps; unless the acid is purified by redistillation and other modes of treatment, the soap made from it is liable to be too much coloured to be made into any other kind of toilet soap than "brown Windsor" and analogous varieties, whilst a peculiar faint sickly odour is liable to be present, requiring moderately strong scents to be added for the purpose of disguising it.

It may be noticed in this connection that "brown Windsor" soap was originally a peculiar kind of soap that had been kept in stock for a long time, and remelted (often several times); so that all the free caustic alkali originally present became carbonated, and the alkaline carbonate ultimately became neutralised entirely, probably by the formation of oxidation-products of a more or less marked acid character spontaneously produced (during the period of keeping or during remelting) by absorption of atmospheric oxygen, to which the deepening in tint and development of brown colour was due. At the present day, however, most of the "brown Windsor" soaps are of a very different character; so far from being almost absolutely devoid of "free alkali" (to which property the reputation of the original "brown Windsor" soaps is mainly ascribable), they frequently contain very considerable amounts of that objectionable constituent; whilst the colour is

not derived from "ageing" (*i.e.*, the effect of long-continued keeping on certain kinds of soap), but either from the use of coarse brown fatty matters, or the admixture of brown ochre or other colouring substances, or both together; in fact, all scraps that have become soiled (including the floor-scrapings of the soap factory) to such an extent that they cannot be utilised in any other way are usually worked up into tablets of the "brown Windsor" class. Accordingly, this variety of soap, *as now sold*, is often found to be highly injurious to extra sensitive skins, although the article *as originally made* is perhaps one of the most innocuous soaps in the market.

Processes of the Second Group.

As already stated, this group of processes may be conveniently subdivided into three classes, according as the operation is carried out at a comparatively low temperature (so-called "cold" processes), at a boiling temperature without extra pressure, or at a still higher temperature under increased pressure.

For the manufacture of soaps by the "cold" process only the simplest appliances are requisite, which is one of the reasons why this process is so largely employed by perfumers and others who prepare their "stock" soaps themselves on a relatively small scale. A pan provided with an agitator is, in point of fact, the only indispensable piece of apparatus; the fatty matters heated to fusion being incorporated with the alkaline leys in the pan, and the thoroughly mixed pasty mass being then turned out into frames, where the saponification is spontaneously completed. When moderately large quantities of fatty matters (a couple of tons or so at a time) are to be treated, a "Hawes" boiler is conveniently used, consisting of an ordinary horizontal cylindrical boiler, with a shaft running through its axis, and provided with vanes, so that, by turning the shaft, the materials inside the boiler are kept well agitated and intermixed. In order to produce a finished product not containing too large a proportion of water, concentrated leys must be used; thus, to make a soap containing not more than some 25 per cent. of water, there must be used for 200 parts of fatty matter some 100 parts of soda ley, containing about 23 per cent. of anhydrous soda (Na_2O) and about 75 per cent. of water, including that present combined with the soda as caustic soda or sodium hydroxide ($NaOH$, or otherwise Na_2O, H_2O):* such soda ley has a specific gravity of about 1·35 to 1·36 (near 37° — 38° Baumé). Soda ley of this strength only saponifies tallow and various other kinds of fatty matter with difficulty, weaker leys being much more effective in such cases, although leys of this strength (or something approaching thereto) are most suitable for rapidly acting on other classes of fatty matter, more especially castor oil and cocoanut oil. It hence often results that perfumer's toilet soaps made by the cold process are not thoroughly saponified, fatty matter not acted upon, and the corresponding quantity of uncombined caustic alkali being simultaneously present; this latter constituent, if present in any quantity, renders such soap most objectionable and deleterious to use for persons possessing tender skins, or for infants or others whose skins are apt to excoriate and chafe, or chap readily. Of late years, processes for making soap at home have been advocated on the ground of economy, kitchen fat and waste grease being saved, and when a sufficient quantity has accumulated, being melted and strained clear, and then well intermixed with a soda ley prepared by dissolving powdered caustic soda in a certain quantity of warm water, the mixture being covered up to keep in the heat, and allowed to stand. The soap thus prepared almost invariably possesses the fault alluded to, *i.e.*, the saponification is incomplete, so that fat unacted upon and uncombined caustic soda are simultaneously present; in consequence, such soap, although possibly very suitable for scrubbing floors, or even for laundry operations, can by no means be recommended for toilet purposes. Somewhat the same remarks apply to a class of products also prepared by cold processes and designated as toilet soaps (but often by no means deserving the name) that have come largely into the market of late years, owing to their attractive appearance rather than to their intrinsic good qualities, viz., *transparent soaps made without spirit*. Although a few makes of this class of article are to be found to which these objections do not so largely attach, yet it is, unfortunately, the fact that the majority of the products of this type are prepared by a modification of the cold process, employing strong caustic leys in considerable excess (without which transparency does not seem to be so readily attainable): the objectionable

* The remaining 2 per cent. being saline impurities, such as chloride and sulphate of sodium. This represents a fairly pure commercial caustic soda; but articles of still greater purity are in the market.

action of this constituent being yet further intensified by the incorporation into the soap mass of a large proportion of *sugar*, which causes the whole to dissolve rapidly, especially in warm water, thus increasing the amount of alkali brought into contact with the skin during use. This class of products will be further discussed hereafter; but it may be noted that, in addition to their other demerits, these articles rarely contain as much as one-half their weight of actual soap, the major half being water, sugar, and saline matters, added to give a fictitious appearance of solidity.

In the manufacture of soft soaps and marine soaps (soaps chiefly made from cocoanut oil, and possessing the property of lathering with sea water), the appliances used essentially consist of a pan or copper, provided with a steam worm or coil of pipe connected with the boiler in such fashion that steam passed through the worm will heat up the contents of the copper. Frequently two worms are provided, one with perforations, so that jets of steam continually pass up through the mass of soap when the connection with the boiler is open, so as to boil up the contents of the copper with "wet" steam; the other without perforations, but connected with a superheater, or high-pressure boiler, so as to give the means of attaining a higher temperature than 100° C. without blowing steam directly into or through the mass, and thus of evaporating water by means of "dry" steam. A curb to prevent frothing over, and a "fan" to break bubbles and froth, are also useful adjuncts. The latter consists of a vane revolving on a vertical axis, and adjustable at different elevations as required on that axis, so that it can be made to revolve at any desired horizontal level inside the copper, or altogether removed therefrom. The method of working varies somewhat in different factories, in some cases the whole of the oil or fatty matter to be saponified being introduced into the copper, and the alkaline ley then run in in portions at a time, and boiled up with wet steam after each addition; in others, the oil and alkali being both introduced in portions at a time. When saponification is complete, the mass is boiled down, so as to evaporate water by means of the dry steam coils. In the case of "marine" soaps, an addition of salt or brine, to give increased hardness, or of silicate of soda, to increase the detergent action, or of both together, is usually made by crutching in the materials to be incorporated before framing or whilst in the frame; soaps thus treated, however, are by no means desirable materials for toilet use, either as one or as constituents in a blended mass, on account of their alkalinity; they are, however, occasionally used. Some Continental makes are improved (?) by the addition of sugar as syrup to the product, giving as result a material which is sufficiently white to permit of tinting all sorts of pretty colours, and consequently of being rendered very attractive in appearance; but the quality of these substances (from the point of view of applicability to the human skin) is usually of the worst possible.

Soft soaps are but rarely used as ingredients in toilet soaps when manufactured into tablets, the presence of potash compounds being usually ensured (when required) in other ways, notably by using a mixture of potash and soda to saponify fatty matters instead of the latter alkali alone, or by pearlashing, *i.e.*, adding pearlash to the re-melted mass. Certain "toilet creams," and analogous cosmetics more or less of the nature of soap, are, however, essentially soft potash soaps. Usually, these substances are prepared by the cold process, using potash only as a saponifying agent, rather than by the boiling process employed in the manufacture of ordinary household soft soap.

Soaps made under pressure, when of good quality, are to some extent used as "stock" soaps, *i.e.*, as the basis of toilet soaps prepared therefrom by refining or blending together, or otherwise treating to improve the quality. The plant used in their manufacture essentially consists of a pressure boiler, into which the leys and fatty matter are introduced, the temperature being then raised until the requisite pressure is attained (which varies with the fatty matters, being the greater the less easily saponified). In Dunn's method of working, comparatively low pressures are employed (20lbs. to 65lbs.), the soda leys being causticised before use; in Bennett and Gibbs' method, carbonated alkali is used in conjunction with much higher pressures (15 to 20 atmospheres), the materials being continuously pumped in at one end of the boiler, and emerging as finished soap, ready to put in the frames, at the other end, and being continuously agitated whilst passing through.

Processes of the Third Group.

In order to prepare soap on the large scale adopted by "soap-boilers" employing the third class of process, in which glycerin is separated from the soap during manufacture,

much the same kinds of pans and steam-pipes are employed as these above described, saving that their dimensions are usually materially greater;* thus coppers capable of holding 30 to 40 tons, and even more, of soap at one operation, are not infrequently used. The products thus formed may be classified into three groups, respectively *curd*, *fitted*, and *mottled* soaps; up to a certain extent the process of preparing all three kinds is the same, the main differences being in the later stages. The fatty matter to be saponified is heated together with caustic ley of sp. gr. 1·05 to 1·09, in quantity not quite sufficient to produce complete saponification, weaker ley being used at first, and stronger being gradually added as the operation progresses; the effect of this is to "kill" the fatty matters or "goods," *i.e.*, to convert them into a kind of emulsion not containing any visible grease. After this operation has proceeded to the requisite extent, a certain proportion of salt (or brine) is added, which causes a separation to take place between the imperfect soap formed and the brine produced by the solution of the salt, the latter sinking to the bottom and retaining in solution the glycerin formed during the saponification; this brine is then pumped away by means of a pump connected with the base of the pan, and the partially finished soap boiled up again with stronger ley so as to complete the saponification. For curd soaps this operation is continued, using the closed steam coils, until by evaporation the soap acquires a peculiar consistency, the leys running away from the curd on standing, owing to the insolubility of soap in moderately strong alkaline leys, just as it is insoluble in brine; the curd is then allowed to stand awhile, and finally ladled or pumped out into the cooling frames (boxes of wood or iron capable of being taken to pieces, and held together with nuts and screws), in which it concretes on cooling and standing, forming solid blocks which are subsequently cut up into slabs some 2½ to 3 inches in thickness, these being again cut into bars weighing some 3 lbs. each. According to the length of time during which the boiling has been continued, *i.e.*, according to the amount of evaporation that has taken place, so is the quantity of water associated with the resulting curd soap variable; when comparatively weaker leys run away from the curd at the close, the soap is more moist than when the final leys are stronger; in any case a certain amount of alkaline ley is apt to remain disseminated through the mass, although the majority of such entangled fluid separates to the bottom of the cooling frames, and runs away through perforations for the purpose; the presence of this ley generally renders curd soaps somewhat alkaline, and hence less fitted for toilet use than for laundry operations. In order to avoid this, when requisite, the curd is boiled up more than once with weaker leys, or with weak brine alone, so as to wash out the entangled caustic solution, the ley that separates after each boil up being run off; notwithstanding, notable amounts of caustic alkali and chloride of sodium are usually present in curd soaps, due to incomplete separation of ley. Recently, a patent has been taken out for the more complete removal of ley, by means of a centrifugal machine, in which the pasty curd is placed, and it is claimed that almost entire removal of leys can thus be effected with proper care; the same result, however, is more frequently obtained by "liquefying" the soap, or "fitting" it, which operation essentially consists in thinning the soap to a great extent with weak leys or water (partly derived from the steam condensed in heating up with wet steam after partial cooling down), boiling up, and then allowing to stand for a long time, when the mass separates into three layers, viz., a frothy scum, or "fob," on the top, and at the bottom an aqueous mass containing iron (from the pans) and other impurities, which, being heavier, separate on standing, and being usually very dark coloured (especially when soda leys are used containing small quantities of sulphide), are known as "negur," or "nigre;" the central portion, or "neat soap" is almost devoid of free alkali from admixed leys, and is usually colourless, or nearly so;* after removing the fob, the neat soap is carefully ladled or pumped off into the cooling frames without disturbing the nigre, which is utilised in the production of mottled soap or other more coloured varieties. The fitted soap thus obtained always contains a considerable amount of water (some 35 to 40 per cent, and some-

* Formerly pans heated by fires underneath instead of steam ("wet" or superheated) were largely employed; but of late years their use has considerably diminished in favour of steam pans, on account of the much greater ease with which the operations can be controlled, besides various other advantages.

* A soap-boiler would compare society at large to a fitted pan of soap rather than to a flagon of ale:—"Fob at top, nigre at bottom, and neat soap in the midst," instead of "Froth at top, dregs at bottom, and good liquor in the middle."

times more); whilst curd soap that has been boiled on comparatively strong ley contains considerably less (some 20 per cent., or thereabouts); the precise amount of associated water depending on the way in which the final boil is effected, and the amount of evaporation taking place therein when dry steam is used. The term "fitting," strictly speaking, relates rather to the production of a mass of a certain appearance or consistency than to the actual degree of purification effected, although the two are intimately associated; thus the soap is said to be of a "fine" or "coarse" fit, according to the amount of dilution, and consequent separation of impurities, which accompanies the development of peculiar degrees of consistency, judged of in practice by taking up a portion of the mass on a trowel and noticing how it slides off therefrom, its appearance as it cools, and so on.

When a curd soap is made from materials that yield, besides soda soap, an admixture of coloured matters derived from impurities (iron soap, alumina soap, ferruginous matters from the pan, sulphide of iron, &c.), the character of the cooled mass varies notably with the amount of water present; if much water be present, an action goes on in the cooling frame analogous to that taking place in the fitting operation during the subsequent standing, *i.e.*, the coloured heavier impurities more or less completely sink to the bottom as a dark-coloured layer; but if the quantity of water be not in excess of a certain amount, and the rate of cooling be properly adjusted, the matters do not subside, but simply segregate themselves into veins irregularly distributed throughout the mass, leaving comparatively uncoloured soap as the matrix in which the veins run. When cut across, such a soap accordingly shows a marbled, or *mottled* appearance. Formerly this appearance was considered a guarantee of quality, *i.e.*, it intimated that the amount of water present did not exceed a certain amount (some 20-25 per cent.); and inasmuch as "mottled soaps" for this reason acquired a reputation, it became customary to enhance the mottle by purposely adding colouring matter, and more especially either iron oxide as such, or solution of sulphate of iron, which, becoming decomposed by the soap, ultimately formed ferruginous insoluble matters in the mass. "Castile" soap thus prepared from olive oil accordingly long enjoyed a high reputation, partly on account of the nature of the oil used in its production, partly from the existence of the mottle in it. Nowadays, however, such "appearances are deceptive" to a high degree: a large amount of misdirected ingenuity has been brought to bear, not only on the substitution of cheaper oils for olive oil (a substitution not necessarily involving a depreciation in the useful qualities of the soap), but also in inventing methods of manipulation, by means of which a mottled appearance can be communicated, notwithstanding that the amount of water present very largely exceeds that compatible with the old-fashioned natural mottle. These methods essentially consist in partially cooling down the watered soap, and when it has gained a particular consistency owing to thickening whilst cooling, stirring in the pigment intended to produce the mottle, the segregation into veins then going on during the further cooling and solidifying, just as in the true mottled soaps, which were equally thickened at much higher temperatures owing to the smaller amount of water present.

Excepting in so far as genuine Castile soap is employed as an ingredient in blended masses, mottled soaps are not used for the preparation of the better kinds of toilet soaps. Some of the cheaper varieties, however, are nothing but ordinary mottled soaps cut and stamped into tablets, in some cases the marbling being effected by means of a comb or blade passed through the mass before complete solidification, and previously dipped in a tinting composition, so as to develop coloured streaks in the mass. Some Continental cocoanut oil soaps of this description, of the vilest character in all respects, are occasionally to be met with. On the other hand, curd soaps and fitted soaps are very largely used as the basis of the better classes of toilet soaps; in fact, a well fitted soap made from selected sound materials is probably the very best basis of the kind that can be obtained; in this country, however, soaps made by cold processes, and curd soaps are employed to an extent probably greatly surpassing that of any other kinds.

Processes of the Fourth Group.

The principal class of manufacturers' soaps coming under this head consists of resin soaps, prepared by intermixing with a boiled tallow or other soap of the curd variety the resin soap obtained by boiling together soda leys and resin; the crude product thus obtained is almost invaribly "fitted" as above described before framing. Many of the resin soaps in use, however, are prepared by acting with alkaline leys *simultaneously* on fatty matters and resin, so that the saponification of the

glycerides and the direct saturation of the resin acids go on side by side.

Resin soaps prepared in one or other of these ways are largely used as ingredients in blended toilet soaps, a more ready degree of lathering, greater toughness, and less liability to crack in stamping being thus gained. Some of the best of the cheaper class of so-called toilet soaps are simply fitted resin soaps of a good grade (preferably "primrose" made with the lightest coloured resin) cut to shape, partially dried, and stamped, either with or without the previous addition of essential oils, &c., to scent the mass.* The coarser and darker resin soaps, however, being usually made from much lower qualities of fatty materials (horse grease, kitchen fat, and similar low-class greases), are not to be recommended for application to the skin, although they are actually used to a large extent in the production of soaps which, being tinted brown, do not require the finer kinds of fats and oils in their preparation, so far as colour is concerned; whilst being strongly scented (usually with cheap essential oils or "mirbane") the more or less pronounced disagreeable odour due to the coarse fats is practically disguised, at any rate for a time.

Manufacture of Toilet Soaps.

The preceding remarks and descriptions of the leading processes employed in the manufacture of soaps generally on the large scale, require to be supplemented by a brief account of certain other processes through which the crude products of the large soap factory are put in order to "refine" them, and otherwise to render them more attractive in appearance and more convenient in use for purposes of personal ablution. As already stated, in the case of many of the cheaper classes of so-called "toilet" soaps, these further processes are wholly omitted, excepting in so far as they relate to the mechanical processes of subdividing the comparatively large blocks obtained in the factory, and stamping into tablet form; but with the better classes of fancy soaps these further processes are frequently of the highest importance.

As regards the manufacture of toilet soaps in general, the subject may be conveniently treated under the following heads:—

I. *Preparation of Soaps by Cold Processes.*—*(a)* Opaque soaps; *(b)* transparent soaps not prepared by dissolving stock soaps in spirit.

II. *Manufacture of Transparent Soaps from Stock Soaps by Treatment with Spirit.*

III. *Preparation of Soaps by Re-melting.*—(*a*) Processes of re-melting single kinds or blends; (*b*) incorporation of ingredients for improving quality or giving special properties.

IV. *Machinery and Appliances employed in the preparation of Bars and Tablets.*—(*a*) Manufacture of "milled" soap; (*b*) appliances used in the formation of tablets from blocks of molten soap.

I.—Preparation of Toilet Soaps by Cold Processes.

(*a*) *Opaque Soaps.*—On account of the simplicity of the plant required for the manufacture of toilet soaps by processes of this class, these methods have long been employed by perfumers and others making comparatively high priced soaps on a scale small as compared with that adopted in large soap-boiling establishments.

In the preparation of perfumes by the process known as *enfleurage*, cakes of prepared fatty matters, and in some cases oils, are made to absorb the volatile odorous matters given off from delicately scented flowers, by exposing the cakes or oils to a gentle current of air passing through or over a mass of the flowers to be treated; or, in the older way of working, by making a pile of alternate layers of flower petals and cakes, and allowing them to stand for a day or two, during which time the volatile essential oils of the flowers are to a large extent absorbed by the cakes, when the pile is taken asunder, and the exhausted flowers replaced by a fresh batch, and so on until the cakes are impregnated with flower scents to the required extent. By macerating in alcohol the cakes thus scented, or by agitating therewith, the essential oils are again largely dissolved out from the cakes of fatty matter or the liquid oils thus treated, producing flower essences used by the perfumer in compounding his various scents and perfumes, and leaving behind the fatty or oily matter insoluble in spirit. This undissolved substance being necessarily composed of fats and oils exhibiting the least possible tendency to become rancid (which, should it occur, would more or less deteriorate the essence ultimately prepared), is a most eligible material for the preparation of a high-class soap, the more so as a certain amount of delicate perfume is always retained; and accord-

* Resin, either alone, or previously dissolved in glycerin, is sometimes added to soap-masses for the preparation of particular varieties of toilet soaps.

ingly the manufacture of soap therefrom by a cold process (so as to avoid dissipating and deteriorating perfume as far as possible) is a branch of business often cultivated by the perfumer. Unfortunately, the necessity of the case prohibiting the application of a high temperature, and perfumers not being necessarily men of profound chemical attainments, the manufacture of perfumed soaps in this way often leads to the preparation of products containing far greater amounts of free alkali than are at all compatible with excellence, when the products are viewed as soaps only; incomplete saponification (causing simultaneous presence of free alkali and fatty matters not acted upon) is often exhibited by such soaps; and when the greasiness thus produced is avoided, it is usually only effected by the employment of a considerably larger proportion of alkali than that chemically equivalent to the fatty glycerides used; so that, in any case, a notable amount of free alkali is more often present than not.

The amount of high-class fatty and oily matter obtained as residues from flower essence preparations being absolutely only small in amount, these materials are usually supplemented with analogous substances of the ordinary type, such as sweet almond oil, clarified beef marrow, refined lard, and the like; often these materials alone are employed. Owing to the comparatively small scale on which the operation is usually conducted by the perfumer, products of this class are sometimes designated "little pan soaps." The fatty matters of selected qualities are first melted together, and strained clear if necessary; then about half the alkaline ley (sometimes caustic soda only, but often a mixture of caustic soda with a smaller quantity of caustic potash) is gradually added with continual stirring, and the whole thoroughly well intermixed; the remainder of the ley is then gradually added with continual agitation, the temperature not being allowed to rise too high (usually not beyond about 65° C.); after which the soap is run into cooling frames, much smaller in dimensions than those ordinarily employed by the boiler of household soaps, covered up, and allowed to stand: usually, the temperature rises somewhat spontaneously, owing to the development of heat as the saponification progresses. Various tinting materials and perfumes are usually added, preferably at as late a period as possible consistent with the possibility of complete intermixture with the mass. Some makers reverse this mode of procedure, the whole of the ley being placed in a suitable vessel provided with an agitator, and warmed, after which the melted fatty matters are gradually added and thoroughly incorporated. In order to obtain a resulting product of proper consistency, leys must be used of such strength that the total mass does not contain more than about 25 per cent. of water; this is effected by using for one hundred parts of fatty matter about 50 parts of ley sp. gr. 1·35 (near to 37° Baumé); such ley, if tolerably pure caustic soda, free from any considerable amount of sodium chloride and sulphate, contains about 23 to 24 per cent. of actual anhydrous soda (Na_2O), and about 75 per cent. of water (including that combined with the soda as hydroxide of sodium); so that about 11·5 parts of anhydrous soda are employed per 100 of original fatty matters. If cocoanut oil (finest quality) be used as a portion of the fatty acid mixture, as is often the case with French toilet soaps, a larger proportion of soda is requisite to bring about complete saponification without introducing too large an excess of alkali than is permissible with fatty matters mainly consisting of stearine and oleine, on account of the much lower mean equivalent of the fatty acids contained therein; pure stearine theoretically requires 10·45 parts of anhydrous soda for perfect saponification, and pure oleine 10·52 parts, whilst palmitine requires 11·54, and cocoanut oil about 14·6 parts.

The great fault of all processes of this class is that on account of the varying amounts of impurity apt to be present in the alkali used, and of the different equivalents of the various fatty acids contained in the material, *it is almost impossible to rely upon obtaining products of exactly the same character by adhering to any routine method of procedure*; if certain proportions are fixed upon as giving a good yield on the average, some batches are liable to contain an excess of alkali to an objectionable extent, and others to contain unsaponified fat on account of the presence of too little actual caustic soda in the leys used to effect complete saponification; these defects being quite apart from the circumstance that it is by no means uncommon to find that unsaponified at and free alkali are simultaneously present, owing to incomplete reaction between the materials employed; for which reasons soaps prepared by boiling and subsequent purification by fitting, or other equivalent processes, are greatly to be preferred to soaps made by

the cold process, more especially as the perfection to which the "milling" process (described below) has now been brought permits of the introduction into the soap mass thus obtained of the most delicate perfumes, with even less liability to deterioration by the action of heat than in the cold process. One advantage, however, cold process soaps necessarily possess over boiled soaps, viz., that the glycerin set free during the saponification is retained as a constituent; but at the present day processes for recovering glycerin from spent soap leys are worked to such an extent as to make refined glycerin but little more costly than fatty matters of good quality; accordingly, it is easy to add glycerin to a boiled soap mass either whilst molten before framing, or during milling, without materially increasing the cost of the resulting product.

(*b*) *Transparent Soaps made by Cold Processes.*—It has long been known that when tallow or other analogous soaps are dried and dissolved in alcohol, the solution obtained when evaporated leaves the soap behind as a translucent mass; the peculiar molecular constitution of soap, as thus obtained, is spontaneously assumed to a greater or lesser extent by certain kinds of soap when prepared by the cold process, notably in the case of castor oil soda soap. Addition of a little spirit of wine, or of more glycerin than is formed during the saponification, greatly facilitates the production of this "colloid" form of soap, whilst the same result is also brought about by the incorporation with the mass of sugar, and to some extent of other substances, notably petroleum. To so great an extent is this result effected when a considerable amount of sugar is added (15 to 30 per cent.) that under suitable conditions tallow may be largely incorporated with the mass of fatty matter used, without interfering with the transparency, provided that the saponification is carried out in such a fashion as to be complete, *i.e.*, that no unsaponified stearic glyceride remains in the product, otherwise muddiness or spottiness is apt to result. In order to make sure that all the fatty matters employed are actually saponified, it is usual in this country to add a quantity of caustic soda solution, notably in excess of that chemically equivalent to the fatty acids (the excess as found by analysis of many kinds of commercial products of British origin usually varying from about $\frac{1}{7}$ to $\frac{1}{4}$ (15 to 25 per cent.) of the soda actually present in the form of soap. Some few makers, however (mostly Continental ones), prepare products containing much less free alkali than the smaller of these amounts. As a general rule, cocoanut oil largely enters into the composition of this class of transparent soaps, often with the result of communicating to the hands or objects washed with the soap a very disagreeable odour.

As an illustration of the nature of the materials used in making this class of soap, the following formula and general directions may be quoted (*Journal Society Chemical Industry*, April, 1883):—

"Melt the following with agitation:—10 kilos. cocoa-nut oil, 10 kilos. castor oil, 8 kilos. neutral tallow, and saponify them at 50° C. with 14 kilos. of caustic soda at 38° B, and continue stirring until pastiness sets in. Add 8 kilos. loaf sugar in $8\frac{1}{2}$ litres of water at 85° C., taking care to bring it in gradually. As soon as the soap begins to solidify at the sides, the boiler is jacketted with a water-bath, kept at 80° C. until it has attained the proper consistency, and the scum has separated. Add 20 to 30 per cent. of loading, agitate well, and then stir in a boiling solution of 1 kilo. crystallised soda in 1 litre of water; dye, perfume, and finish off the batch as usual."

The "loading" here mentioned is made from mineral oil and soap shavings, the petroleum being previously deodorised by means of bleaching powder solution and hydrochloric acid, and subsequently treated with chalk to remove adherent acid. "30 kilos. of purified oil are heated to 50° C., mixed with 2 kilos. of well dried soap shavings, and heated until a sample on being taken out solidifies on cooling."

It is evident from the formula that even without the "loading," the resulting mass would not contain as much as half its weight of actual soap, for the ingredients consist of 28 kilos. fatty glycerides (representing a little more than the same weight of anhydrous soda soap, about 29 kilos.), and $32\frac{1}{2}$ kilos. of water, soda, and sugar; so that when 30 per cent. of loading is added, the resulting mass would not contain much more than one-third its weight of actual soap. On the other hand, the total alkali used (partly as caustic soda solution, partly as crystals) represents about 113 per cent. of the amount chemically equivalent to the fatty matters, furnishing consequently a soap with an excess of "free alkali," equal to about one-eighth of that present combined as soap; a quantity, as will hereafter be seen, very far in excess of that compatible with good quality as regards injurious action on tender skins. The quantity of sugar prescribed, it may be noticed, represents some 13 per cent.

reckoned on the mass without "loading," and about 27 per cent. of the actual soap formed.

This formula, apart from the loading, results in the production of an article of distinctly better quality than most of the transparent soaps of this kind now sold in Great Britain; for these soaps usually contain a still larger excess of alkali (ranging from 15 to 25 per cent. of that present combined as actual soap), and a still higher per-centage of sugar (20 to 25 per cent., and even more, being often found); whilst the amount of actual soap in ablets fresh from the factory (and not dried by exposure in shop windows) rarely exceeds 45 per cent., so that these articles are about as much a compound of sugar candy and soda crystals as they are soaps, if not more so.

It should, however, be remarked that a few makes of the better class of this variety of transparent soap are to be met with, not containing so large an excess of alkali, and not so large a sophistication with sugar; the transparency being, in some cases, largely brought about by the admixture of a certain amount of spirit, or glycerin, or both, with the mass in the final stage (the spirit, however, not being applied in the way employed in the manufacture of the "spirit-made transparent soaps" hereafter described). Such a product (excepting as regards free alkali, which is still in marked excess) is obtainable by adopting the following formula:—Heat to 65° C. a mixture of tallow, 20 parts; palm oil, 12 parts; castor oil, 8 parts; and then gradually run in 20 parts of caustic soda ley, at 38° B.; when intermixed, crutch in 20 parts strong alcohol, and subsequently 20 parts of glycerin, and 10 of syrup, containing half its weight of loaf sugar. Colour and perfume *ad libitum*.

Did time and space permit, numerous other formulæ in actual use for the preparation of cold process transparent soaps might be quoted, all more or less of the same general character, viz., that they result in the production of a compound of a variety of soap (not by any means always intrinsically of the choicest kind), with more or less toffee and washing soda, and a liberal proportion of water; so that, even when the finished tablets are sold at a price materially lower than that at which a really good genuine toilet soap can be produced with a reasonable margin for honest profit, the value received by the purchaser (reckoned on the *quantity* of actual soap present, and irrespective of its *quality*) is usually less than he would obtain by buying a much more highly priced opaque genuine toilet soap. The "Philosopher of Chelsea" is credited with an unkind remark to the effect that the population of the United Kingdom is "some thirty millions, mostly fools;" but in truth, the magnitude of the trade now done in this class of transparent soaps (often of a character only to be described as simply abominable for the purpose of application to sensitive skins) just because they are pleasing to look at, would go far to vindicate his memory from the charge of sarcastic exaggeration which at first might appear to attach thereto.

II.—Transparent Soaps Made from Stock Soaps by Solution in Boiling Spirit.

This variety of soap, when properly made, has the merit of containing much larger proportions of actual soap than the transparent soaps made by the cold process just discussed, whilst it ought to be almost devoid of free alkali, since solution of dry soap in strong spirit leaves alkaline salts other than soap undissolved; unfortunately, a good deal of the transparent soap made (nominally at least) by this process is found on analysis to be open to other serious objections, which, however, are in no way applicable to all the different makes sold in this country.

It has long been known that ordinary household soaps, when more or less deprived of water and dissolved in strong spirit of wine, are thus separated to a great extent from saline matters, such as sulphate and carbonate of soda; so that the solution thus obtained usually contains a less amount of free alkali relatively to the actual soap present than was originally present; and further, that the alcoholic solution thus obtained furnishes by distilling off the spirit, a mass of purified soap which is more or less clear and translucent after standing until the last traces of spirit have almost completely evaporated. Accordingly such purified soaps, made from first-class fatty matters in the first instance, have long enjoyed a deservedly high reputation as toilet soaps, not only on account of their pleasing appearance (especially when judiciously tinted), but also on account of their freedom from irritating action on sensitive skins through the absence of free alkali in any notable quantity. Further, an admixture of purified glycerin with the mass has long been known as improving the soap, not only by aiding the transparency, but also by rendering the mass more bland and emollient in use; whilst certain

kinds of resin, or of resin and glycerin jointly, also produce much the same effect. Unfortunately, but little of the transparent soap in the market nowadays is of this old-fashioned admirable type; the cost of alcohol in Great Britain, on account of duties, has induced manufacturers to substitute methylated spirit for pure alcohol, with the result not only of communicating to the product a coarse rank odour (more especially noticeable after keeping till the perfume added to disguise the smell has evaporated), but also of impregnating the mass with substances which, in some cases at any rate, are liable to act injuriously on the skin. When this evil is aggravated through the desire of further cheapening the product, firstly, by the use of coarse fatty matters for the preparation of the original stock soap, and secondly, by the substitution of sugar for glycerin, the result is the production of an article which is often very far inferior to the older excellent makes of this class of soaps; for although irritation to sensitive skins, caused by the presence of free alkali, is avoided (carbonate of soda being left undissolved by the alcohol employed), yet at least equally unpleasant effects are liable to be produced (in certain individuals, at any rate), either from rancidity of fatty matters originally employed, or empyreumatic matters from the methylated spirit, or both conjointly. Several members of my own family, as well as various friends, are unable to use this sort of soap without the almost invariable production of blotching or cracking of the face-skin, or other similar inconveniences.

From the point of view of the method of manufacture, the class of soaps now under consideration is quite distinct from those varieties of "cold process" soaps which are rendered transparent by the intermixture of alcohol with the mass at a certain stage of the operation, although the physical effect upon the resulting soap is much the same in each case, a colloid modification being thereby generated. In particular, the cold process transparent soaps are practically (though not necessarily and unavoidably) always intensely alkaline; whilst the true spirit-made transparent soaps now under discussion are (when properly prepared) practically neutral, partly because they are usually made from fitted soaps containing little or no free alkali, and partly because the solution in alcohol eliminates alkaline salts to a very large extent, if not entirely, should they have been present in the original stock.

During the process of solution, which is effected in a covered vessel forming a kind of still, the alcohol vapour given off is condensed by a worm, either running back to the dissolving vessel, or being kept apart. It is stated that crude methylated spirit, when first used for thus dissolving soap, furnishes a much less unpleasantly smelling distillate, and a similar improvement takes place at each subsequent time of using, so that ultimately a spirit is obtained nearly free from the rankness of the original substance, and consequently capable of giving a much better product, especially if employed to dissolve a better class of stock soap. If a transparent soap containing a high per-centage of soap is required, it is indispensable that the residue left in the still, after distilling off as much spirit as possible, should be exposed to slightly warm air for a lengthened period, in order to allow of the removal by evaporation of the last portions of alcohol and water (the latter mainly being that originally contained in the stock soap, which, though usually shaved and dried, as subsequently described in the case of milled soaps, is rarely rendered actually anhydrous before treatment). Complete transparency, in fact, is not shown by the raw product, which is usually very muddy until clarified by long standing and evaporation of alcohol, &c. The development of perfect clearness is considerably facilitated by the presence of glycerin or cane sugar to the extent of some 10 to 15 per cent.; resin soaps, other things being equal, usually yield clearer products than soaps not containing resin. A good "primrose" soap thus clarified, and rendered transparent by solution in alcohol, furnishes a product very little coloured, about the tint of very light golden sherry; most of the transparent soap of this class as sold, however, is much darker, probably from the use of cheaper and darker stock soaps, or from the development of colour either by alteration of certain constituents in impure alcohol, or by the action of air upon the original stock soap, causing browning. In order to obtain a product of uniform appearance, the lighter coloured batches can be deepened in tone by addition of caramel or other convenient soluble colouring matter.

III.—Remelted Soaps.

(*a*) *Process of Remelting.*—A considerable fraction of the various toilet soaps of British make are prepared by blending together different varieties, by the simple process of remelting them together in a pan provided

with a steam jacket. Sometimes the bars to be melted are arranged vertically, or horizontally, around the sides of the pan, in which a little water is first placed to avoid drying, and are left to themselves to soften and run down gradually, more being similarly added from time to time, and the whole mass being finally well intermixed by stirring or "crutching" by hand, and then cast in frames of smaller dimensions than those usually employed by the soap-boiler; in other cases, the pans are provided with mechanical stirring or crutching arrangements, worked either continuously or intermittently; sometimes, to facilitate the fusion, the bars of soap employed are reduced to chips or shavings by means of a kind of plane worked by hand, or by a rotating blade affixed to a disc, and acting on the same principle. Certain practical minutiæ require to be carefully attended to, in order to obtain a good result with certain kinds of soaps, more especially when several varieties are to be blended together; thus, if the heating be carried on too long in certain cases, the mass thickens in consistency, not merely from drying by evaporation, but also in consequence of a physical alteration in texture; if too much agitated, especially with a rotary stirrer, there is a liability to incorporate air bubbles with the mass, rendering it vesicular and spongy, which is apt to deteriorate the finish of the tablets ultimately formed, although it communicates to them the convenient property of not sinking in water, so that when in use, the tablet does not subside to the bottom of the bath or basin, but floats. If incompletely heated or stirred, small masses of unfused soap are disseminated throughout the whole like plums in a pudding, giving a spotted and speckled appearance, especially when colouring matters are added so as to tint the soap. Such colouring matters, when added in the form of pigments, require to be thoroughly ground and levigated, so as to reduce them to impalpable powder, otherwise they are apt to render the soap gritty; when soluble colours are used, they may conveniently be previously dissolved in some appropriate menstruum, such as alcohol or a boiling aqueous solution of soap. Pigments containing poisonous metals, especially mercury, lead, arsenic, and copper, should be carefully avoided; for although the presence of small quantities of insoluble compounds of these metals in the lather produced during use is not likely to effect persons with healthy skins, there is a possibility, in certain cases, of injurious action; and all such contingencies, even though very remote, should be avoided in a high-class article. At the present day, however, vermilion, red lead, and analogous poisonous metallic pigments of this class, are frequently used, principally because soaps thus tinted will bear exposure to light without fading, whilst if organic (natural or artificial) non-poisonous colours be employed, there is frequently a great liability to bleaching of the colour by exposure to light, for example in a shop window.

(*b*) *Intermixture of Ingredients for the Purpose of Improving Quality.*—It is obvious that the process of remelting and blending together various kinds of stock soaps is not capable *per se* of diminishing the average amount of free alkali present in the materials; but by the addition of suitable ingredients to the mass, more or less complete removal of free alkali may be brought about. In certain cases this result is to some extent effected by incorporating with the mass a small per-centage either of resin (alone or dissolved in glycerin), or oleic acid, or even palm oil or other easily saponifiable glyceride, a partial saponification then taking place, so that the excess of alkali becomes more or less neutralised by combination with fatty or resinous acids; but these methods are by no means universally applicable with advantage, although in certain cases they are highly convenient, more especially for scouring soaps used in certain industrial processes in connection with textile fabrics. Boric acid has also been employed for the purpose, the product of its combination with the excess of soda (borax) being well-known as a useful variety of detergent analogous to silicate and aluminate of soda, more especially in soaps intended for the laundry, borax being reputed to have a whitening action on linen, &c., cleansed therewith; whether it is of equal advantage when applied to the human skin, however, may well be doubted.

Certain metallic salts, notably sulphate of iron, have for many years been used as an admixture in various highly esteemed soaps, their action partly consisting in neutralisation of free alkali by combination therewith of the acid of the metallic salt, whilst the metallic oxide is set free and serves as a colouring matter; thus "Castile" soap of the old-fashioned kind (a far superior article to much now sold under that name) is produced by adding sulphate of iron to the curd, so that some of the free alkali becomes converted into sulphate of soda, whilst the oxide of iron formed as complementary product ultimately gives rise

to the peculiar mottle characteristic of that kind of soap. Of course the modern mottles formed by incorporating oxide of iron as such, or analogous pigments, are incapable of producing any action of the nature of diminishing the free alkali by neutralisation, there being no constituent capable of so acting in the colouring matters used.

Metallic salts, other than those of iron, have usually the disadvantage, not only of introducing into the composition metallic substances often of an objectionable character, but also (like iron) of developing more or less marked colour in the mass, so as to interfere with the production either of untinted products or of tablets tinted to fancy; it is evident that if instead of a metallic oxide remaining permanently in the mass, there could be developed a volatile substance removable by evaporation, these objections would be obviated, whilst the advantage of neutralisation of excess of alkali would be retained. Such a result I have recently found to be brought about by the employment of a salt of ammonia (such as the chloride or sulphate) which, when incorporated with the soap in quantity chemically equivalent to the amount of free alkali to be eliminated (a proportion readily ascertainable by analysis of the materials), gives rise to the production of a neutral alkaline salt by the reaction of the ammoniacal salt on the free alkali, and of free ammonia mixed with more or less carbonate of ammonia (according as the free alkali was caustic or carbonated), which latter compounds evaporate and are removed, partly at the moment of intermixture, but more especially during the subsequent mechanical processes through which the soap has to be put in order to prepare finished tablets, the slabs, bars, and partly formed tablets, &c., being necessarily exposed to the air for drying and hardening before the finished tablets are fit for boxing and sending into the market, during which period practically all the ammonia and carbonate of ammonia evaporate. Even should traces of ammonia be retained, they are of no practical consequence, inasmuch as this form of alkali, as is well known, is comparatively destitute of the corrosive action on animal tissues exerted by the fixed alkalies—potash, and especially soda, whence the use of ammoniacal fluids in certain stages of the woollen industries where fixed alkalies would seriously injure the fabrics. Accordingly the patented processes founded on these observations afford a simple and convenient method of getting rid of that *bête noire* of the toilet soap refiner, the uncombined alkali naturally present in the stock soaps employed by him as received from the soap boiler and wholesale manufacture. Obviously the de-alkalisation by this process can also be carried out in the preparation of the stock soaps themselves.

It is of interest to notice that a want of chemical knowledge sometimes leads inventors to take out patents for processes which in practice lead to results quite the opposite of those intended. Thus, a recent patent recommends the incorporation of bicarbonate of soda with soap as an ameliorating agent; it is true that if the excess of alkali were present in the *caustic* state, it would become carbonated by the action of this ingredient, just as it would by simple exposure to air so as to absorb carbonic acid; but this effect would be obtained at the cost of *doubling* the total amount of free alkali originally present, a second equivalent being actually introduced by the (supposed) ameliorating agent.

Besides processes for "refining" soaps during remelting, by removal of excess of alkali by means of the addition of suitable ingredients, many methods are in use for preparing fancy soaps of different kinds, by intermixing therewith small quantities of materials added for the purpose of communicating special characteristic qualities; and in many cases notable amounts of cheap ingredients are also intermixed for the purpose of increasing the bulk by addition of "filling." The various bodies thus added naturally fall into three classes, viz., (1) substances which are added in small quantity, not as "filling," but in order to improve the quality, and which actually do produce that result to a greater or lesser extent, without introducing any serious counterbalancing injury to the product as a whole; (2) substances added in quantity as "filling," but not producing any serious injury by their own nature; and (3) bodies distinctly objectionable in their nature when intermixed with soaps intended for habitual everyday use by the general public, and not under special medical advice.

Amongst bodies of the first class may be mentioned certain finely-powdered roots, &c. (*e.g.*, *orris*), used as perfuming agents, *vaseline*, *spermaceti*, *beeswax*, *ozokerite*, and analogous substances employed for the purpose of developing a bland emollient kind of feeling in use. *Glycerin*, either in the quantity formed by the natural saponification of glycerides (as in the cold process), or added in addition to a further extent, may

also be fairly ranked amongst these substances, *i.e.*, when employed in a sufficiently pure state.

Amongst the substances of the second class which can hardly be regarded as absolutely injurious, although their presence is at least of doubtful benefit, may be noticed the following, when added in such quantities as to act as "filling" or cheapening agents:—*Oatmeal, flour, gluten, gelatin, dextrin, bran, starches* of various kinds, powdered *steatite* and *french chalk*,* *china clay, pipeclay*, and *fuller's earth*; and purified *petroleum* (in transparent soaps).

The following substances may be named as materials belonging to the third class, *i.e.*, substances used for incorporation with so-called "toilet" soaps, the absence of which would be far preferable to their presence, no benefit of any kind, but distinctly the reverse, accruing to a tender skin from their employment:—*Sawdust*, and *woody tissues* not in impalpable powder, *sand, pumice stone*, and *gritty matters* of all kinds, unrefined *petroleum and shale oils*, crude *coal and wood tars, napthaline, creosote*, and analogous *coal tar oils*,† and, *par excellence, alkaline salts* of all kinds, especially *pearlash, soda crystals*, and *silicate of soda*. Any large admixture of neutral salts, such as sulphates and chlorides (several per cents), added as hardening agents to hide watering, is also to be deprecated, the more so as they usually accompany the use of inferior materials in the first place.

Besides the substances above-named, various other ingredients belonging to one or other of the three classes have from time to time been brought forward and sometimes re-patented more than once. Amongst such bodies may be mentioned free ammonia solution, added for the purpose of increasing detergence without correspondingly increasing the corrosive action on the skin that alkalies and alkaline salts (even borax) tend to exert. The difficulty experienced in preventing the almost complete loss of the ammonia by evaporation on keeping awhile has hitherto prevented these soaps from being largely used: one patentee attempts to get over the difficulty by coating the ammoniated soap tablets "with a case of suitable soap or washing compound or soluble or other substance," whilst another is under the impression that mixing oil of turpentine with the mass will prevent the evaporation of the ammonia.

* Sometimes these materials are stirred up with water to a thin paste, which is run into the remelted soap and well incorporated by crutching, the final product being sold to a credulous public as "milk" soap! When dissolved in hot water, and the liquid allowed to stand, the white clayey intermixed matter subsides, and is readily discernible.

† A large variety of "medicated" soaps, containing more or less considerable quantities of substances referable to the disinfectant class, are in the market. In a large number of cases, the amount of medicating material thus incorporated (thymol, terebene, eucalyptus oil, oxidised turpentine oils, camphor, and similar materials) is so small relatively to the mass of soap as to have little more influence on the qualities of the whole than the essential oils, &c., used as perfumes. Such soaps, when otherwise of good quality (by no means invariably the case), may generally be used for toilet purposes with safety, even by persons possessing pretty sensitive skins; but when any considerable quantity of a powerful agent (such as carbolic acid, or coal-tar oils containing it) is present, such soaps *should only be used by tender-skinned individuals under medical advice*. In certain cases, the impregnation of soap with drugs (such as mercurial preparations) forms a most convenient way of exhibiting the latter to patients requiring them; on the other hand, various soaps exist which claim to contain curative agents not really present at all—*e.g., sulphur*. The use of powerful disinfecting soaps in sick chambers and for nurses, for washing linen, furniture, &c., in case of illness, and similar purposes, is, of course, an entirely different thing from the habitual employment under ordinary conditions of such soaps for the usual personal ablutions; but it may well be doubted, even in these cases, whether it would not be preferable to use ordinary soap, and simply dissolve the disinfecting material to the required extent in the water employed.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The number of visitors to the Exhibition for the week ending Tuesday, 27th October, was 112,060 Total since the opening, 3,529,810.

*APPENDIX TO MR. ALEXANDER J. ELLIS'S PAPER ON "THE MUSICAL SCALES OF VARIOUS NATIONS," READ 25th MARCH, 1885.**

SECTION IX. BURMAH, p. 506.

In the Historic Loan Collection of Musical Instruments, at the Inventions Exhibition, 1885, were shown Sir Harry Verney's *Collection of Javese Instruments, formerly belonging to Sir Stamford Raffles*. The special Javese portion is considered in Section XIII below. Among them, however, was a Burmese *Patala*, judging by the ornamentation of the case, the different shape of the resonance box, and the scale, which is heptatonic as in Siam (see next Section).

* The following appendix contains additional information for the musical scales of Burmah, Siam, Java, and Japan, obtained through the Inventions Exhibition.

The instrument contains 20 wooden bars, with sufficiently correct Octaves. Mr. Hipkins and I measured bars VIII to XV with the following results, stated as for the Patala in my paper (p. 506,) than which the present one was evidently more correctly tuned:—

Vib.	362		400		450		486		539		606		644		726
Bars	VIII	175	IX	205	X	132	XI	181	XII	202	XIII	105	XIV	208	XV
Cents	0		175		380		512		693		895		1000		1208

Section X. Siam, p. 506.

The only Siamese scale which could be given in my paper of the 25th March, was taken from a Ranat in the South Kensington Musenm, and was quite enigmatical, for a reason I shall be able to assign presently. Since then the Court Band, which the King of Siam has sent to the Inventions Exhibition, has enabled the general public to hear and appreciate Siamese music; and by the kindness of the Siamese Legation, for which we beg to tender our best thanks, Mr. Hipkins and myself have been given every opportunity of examining the instruments, hearing them in private performances, and interviewing the musicians with the help of the official interpreter, Mr. Loftus. The musicians are a most intelligent-looking set of men, with fine foreheads (not seen in their public performances, on account of their uniform caps), and perfectly understand their work. Some of their solos are really very remarkable performances. Although their music is entirely different from ours, it must take a high rank among extra-European music, which is not adapted for harmony. It is this absence of harmony and presence of simultaneous performance, having its own peculiar but decidedly non-harmonic character, that gives a European, so accustomed to harmony that he is apt to forget it is a comparatively recent discovery, an opportunity of appreciating what must have been the effect in early times when people heard "the sound of the cornet, flute, harp, sackbut, psaltery, dulcimer, and all kinds of music" playing together, and relying for their effects, not on harmony, but on diversity of quality of tone for the same note, or its Octave, or flashing away into labyrinths of eccentric discant, but returning duly to the original theme of which these flourishes were but the embroidery. We may thus learn to see that extensive pieces of music can be put together, with a full appreciation of the relation of parts to a whole, relying solely upon melody without harmony, and come to understand that the latter art, however indispensable to modern European music, is not essential to the existence or enjoyment of music in general. It is seldom that European musicians have had such an opportunity of hearing good music well performed, of a character so strange to their ears, and at the same time so archæologically instructive.

The principal instrument of the Siamese, by which all the others are regulated, is the Ranat Ek, or treble wooden harmonicon. This consist of bars of wood, slightly rounded on the upper surface, suspended by strings passing through their nodes, and strung over what may be called the elevated prow and stern of an ornamental boat or cradle, which serves as a resonance chamber, and also as a storage place for the bars themselves when rolled up, and the hammers by which they are struck. These resonance boxes are often elaborately ornamented, and there are many beautiful specimens in the Siamese Court at the Exhibition. The wooden bars are tuned roughly by measurement, and hollowing out at the back between the nodes, as in the Javese gambangs, and more accurately by sticking lumps of wax, mixed with lead and oil, to the under parts of the bars beyond the nodes. The intonation depends especially on these tuning lumps, and it was because they had fallen off and been lost, or had been ruthlessly cleaned off, that the Ranat we previously examined had such a hopelessly unintelligible scale. But in attaching these lumps the Siamese tuner seems to be guided solely by ear, and the peculiar intention of their scale, to be presently explained, rendering this very difficult, the result obtained is by no means always perfect.

From the Ranat Ek is tuned the Ranat T'hoom, also of wood, but an Octave lower, and next, two metal harmonicons, the Ranat T'hong, brass, treble, and the Ranat Lek, steel, bass. These metal harmonicons are tuned by filing, and they keep their pitch better than the wooden harmonicons. The bars are not strung, but rest on a ledge passing under the nodes.

The Siamese seem to have borrowed from Java the kettles or bells, there called Bonang, and in Siam termed K'hong (bell or gong); but the arrangement is quite different. In Java they are suspended on girth and arranged in square tables. In Siam they are suspended by strings, which tightly fix them in a framework forming a segment of about three-quarters of a circle, within which the player squats, so that he can reach the whole scale, which, on account of the width of the K'hongs, would be too long if displayed in one line like the bars of the Ranat. There are two kinds of K'hong, the Yai or large (used generally for out of doors), and the Lek or small. The sound is bell-like, but like bells, full of inharmonic proper tones. They are tuned by lumps like those of the Ranat, placed inside the bell.

These Ranats are supplemented by other instruments. First, the stringed instruments of the viol kind, the Saw Tai, resembling the Arabic and Persian Rabáb, and the Saw Chine, which is the Chinese two-stringed fiddle. The latter is not so much used, but the Saw Tai (pronounced like the English saw and tie) is a very prominent and beautiful instrument. It has a heart-shaped body, with a very long neck, and a foot, both cylindrical, the former carrying the

pegs for the strings, the latter forming a rest for the instrument when played. The musician squats cross-legged, and holds the Saw Tai at a slight slope. The foot is about twelve inches long, pointed, and in the instrument I examined, was of ivory beautifully carved. The lower part of the neck was also of carved ivory, and the upper part of gold enamelled. The back of the body of the instrument is formed of cocoanuts, jewelled, and the front is a piece of parchment, on which rest the bridge, and also a jewelled disk as big as half-a-crown, but thicker, serving, apparently, to quench the inharmonic proper tones of the membrane. The strings of silk cord are close together at the top, where they pass under a ligature round the neck, and then on to the pegs. The vibrating length of the string from this ligature to the bridge is 360 millimetres (14·15 inches). The strings were apparently intended to be tuned in fourths. The Siamese Fourth is intentionally sharp, as we shall see, but the tuning of a Saw Tai in our presence gave slightly flat Fourths. The pitches of the strings when tuned (taken to the nearest vibration), were 200, 264, 349 vib., whereas true Fourths would have given 200, 267, 356 vib., and Siamese Fourths 200, 269, 362 vib.

The curious part of this instrument to European violinists, but one in which it specially resembles the Rabâb and the Chinese fiddles, is the absence of a finger board. The length of the string is therefore not limited, as on the violin, by pinching it between the fingers and the finger-board, but by pressing with the whole width of the finger on the strings, and as this can be done with very different weight, the note is not constant for the same length of string. The string also not being sharply limited, the tone is not crisp and well defined, but rather hazy. Still considerable execution is possible. The instrument is played with an enormous bow, bigger than our double bass bow, but the hairs are fastened at once to the back of the bow near the hand, and not to a sliding piece as in the European violin bow. In the Chinese fiddle, the hairs of the bow are inserted between the two strings, so as to play either at pleasure.

The most curious of the stringed instruments is the Tak'hay (rhymes English say) or "crocodile." This has also three strings probably tuned in Fourths, and they pass over a series of eleven frets, which are really rather wide-topped movable bridges. This instrument has something like a guitar body, and is placed on the ground, the player squatting beside it. He touches the strings on the frets with his left hand, and sounds the string by a plectrum, like a large ivory tooth, which is fastened to his fingers and drawn rapidly backwards and forwards across the string so as to produce an almost continuous tone, which is not unlike that of a violoncello. We heard some solo playing on this instrument with considerable execution.

The Saw Duong, and Kra Chapee (guitar) we did not examine.

Of the wind instruments we only examined the Pee, a species of harsh oboe, fit only for playing in the open air, and in quality of tone much resembling the Chinese So-na (see paper, p. 516, No. 2), with the effect of a very powerful bagpipe. It is a reed instrumeut, rather thick, with six holes, in groups of four and two, with a considerable space between the two groups, but only three of the first four were covered with the fingers of the left hand, and the fourth hole was covered with the forefinger of the right hand. There were no keys, but nevertheless the player brought out two complete Octaves. The player seemed able to vary the pitch at pleasure, and the consequence was that we were unable to take, down the scale.

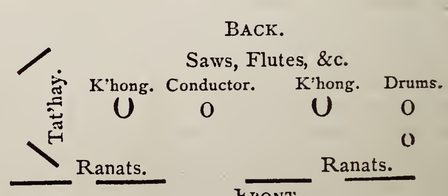
The Klui (rhymes German *pfui*, or French *Louis*), a kind of flute, in which the sound was produced by a membrane over one hole, we were unable to examine as it was out of order.

The P'han, a kind of gigantic Chinese Shêng. comes from the Lao, tributary states to Siam. The pipes are at least 4 feet long, and it is blown, or sucked, at a hole coming from an ivory cross band, against which the palms of the hands rest to hold it in position, while the fingers touch the holes in the pipes, which allow the reeds to sound, just as in the Shêng. It does not form part of the regular band, but is played as a solo occasionally.

Besides the above, were three species of drum First, a small "tom-tom," called Talot-Pote, played with the fingers of the hand, which, like the P'han, comes from the Lao states. Second, a larger species supported horizontally on a stand, looking very like a small keg of beer, and also played by the hand. This is, however, Siamese, and its name is Taphone. Third, a pair of handsomely ornamented drums of a much larger size. The outside of the case, which is still of the cask pattern, is coated with mother of pearl and enamel. These drums are tilted slightly, so as to be easy to play by one performer with a drumstick in each hand, like our kettle-drums, and have a sweet musical tone. They are tuned by placing or sticking a handful of mashed boiled rice at the bottom of the drum. And lastly there are cymbals, called Charp.

The conductor beats time by means of an instrument called Ching, consisting of two small brass cups connected by a string, one being held in the left hand, and the other struck down upon it with the right at the beginning of each bar.

The disposition of these instruments in the orchestra is generally as follows, but the conductor has the liberty of rearranging them as he pleases.



All these instruments, as they had to be played together, just as all the instruments in a European orchestra, were intended to play one and the same scale, having all the notes of the same name strictly unisons, or Octaves one of the other. But just as Europeans have not contrived to effect this very desirable result, so also there were deficiencies in the instruments we examined. The unisons were, however, fairly accurate, and with tones as fugitive as those of the harmonicons the errors made were not perceptible. We examined the vibrations of the copies at the Siamese Legation in June, 1885, of the Ranats Ek, Lek, and T'hong, and took the cents on the Tak'hay by means of the Dichord. The K'hong was tried with the Ranat Ek and found very fairly in tune with it. These were not those played in public, for the latter were preserved at the Exhibition, and most probably their intonation was slightly different. As specimens, we may take an octave of the Ranats Ek and Lek, the vibrations and cents being taken to the nearest whole number. The names of the notes are as follows:—

I. T'hang = Sound.
II. Rong T'hang = Second or under sound.
III. Oat = Voice.
IV. Klang = Centre or middle, from its position.
V. Phong oar, merely the name of the fifth tone, without any other special significance known to the musicians.
VI. Kruert = Sharp sound.
VII. Nork = Outside.

The Octaves of a note have all the same name as the note itself. There are three Octaves, or rather Septimes of seven notes, called upper, middle, and lower Septime. The eighth note is reckoned as part of the next Septime. The Septime in which a piece is played is announced by the conductor. The ranats we examined began on the IVth note, but this is not the case with all, and I have omitted the first four notes in order to begin the series properly.

Above each note in the annexed Table, marked as I, II, &c., of the above series, I place the number of vibrations observed, and between these notes the number of cents (or hundredths of an equal semitone, see my paper p. 487, note †) in the interval between them. After the observed I give the number of vibrations which theory requires, to show how nearly they were reached.

SIAMESE SCALES.

Observed—															
Ranat Lek—															
Vib.	285		316		358		386		421		458		511		562
Cents	I	177	II	219	III	127	IV	150	V	149	VI	148	VII	167	I
Ranat Ek—															
Vib.	285		317		349		383		429		471		522		577
Cents	I	185	II	165	III	160	IV	200	V	159	VI	178	VII	174	I
Theoretical—															
Vib.	285		315		347		383		423		467		516		570
Cents	I	171	II	171	III	171	IV	171	V	171	VI	171	VII	171	I

While we were engaged taking these pitches at the Siamese Legation, Prince Prisdang* told us that the intention was to make all the intervals from note to note identically the same. This would give the above division of the Octave into seven equal intervals, each containing 171·43 cents (logarithm ·043004). In order to test the correctness of this information, I made a finger-board for my dichord (described in my paper, p. 486, note * No. 1.), on which I could play such a scale, and I played it before the musicians at the Siamese Legation. They unanimously pronounced the scale good. I then played the scale I had heard from the Ranat Ek, and they said it was out of tune. This experiment may be considered decisive. The ideal Siamese scale is, consequently, an equal division of an Octave into seven parts, so that there are no Semitones and no Tones, when the instrument is properly tuned, but only intervals a trifle less than $1\frac{3}{4}$ Semitones, for 7 of these would give $12\frac{1}{4}$ Semitones, just over an Octave. Taking, then, the theoretical intervals in cents from the lowest note, we have—

I	II	III	IV	V	VI	VII	I
0	171	343	514	686	857	1029	1200 cents.

We see, then, that IV is sharper than a perfect Fourth (498 cents) and V flatter than a perfect Fifth (702 cents), while III is neutral (lying nearly halfway between a minor Third of 316 and major Third of 386 cents), and VI is also neutral (lying about halfway between a minor Sixth of 814 and a major Sixth of 884 cents). These theoretical peculiarities were, however, not well brought out on the instruments themselves as actually tuned. Thus, taking the cents from the lowest note of the Octave, we find—

* Prince Prisdang is not a brother of the king, but was honoured with that title on account of his services to his country. He is the Siamese Envoy Extraordinary and Minister Plenipotentiary for Paris, Berlin, Vienna, and the other capitals of Europe. He is evidently a highly intelligentleman, speaking English remarkably well, and was very obliging to us; and without his assistance, for which we are much indebted, we should have had great difficulty in divining the theoretical scale.

	I	II	III	IV	V	VI	VII	I
Ranat Lek	0	177	396	523	673	822	970	1137 cents.
Ranat Ek	0	185	350	510	710	869	1047	1227 ,,

It is thus seen that in Ranat Lek the III was actually sharp, and the VI nearly minor, although in Ranat Ek they are both fairly neutral. But, indeed, the Octave was 63 cents flat in the first, and 21 cents sharp in the second. It is the intentional neutrality of the III and VI, as in the Bagpipe scale, which allows Semitones to be dispensed with, and, at the same time renders anything like harmony impossible.

As the absence of harmony renders the tuning of the intervals so difficult, it is interesting to observe how near the tuners in the cases examined came to the ideal interval of 171·43 cents. The following is a record of 52 such intervals actually measured, in cents:—

90 118 127 129 132
140 144 144 148 149 149 150 159
160 160 160 161 162 162 164 164 165 165 166 167
170 170 172 174 174 175 177 178 179 180 182 185
190 192 192 193 197 198
200 200 202 208 208 211 217 219 219

It is thus seen that that the deviation in the direction of a Tone was more frequent than that in the direction of a Semitone, which might be expected, as 171 is much nearer 200 than 100. The 24 intervals of from 160 to 185 cents represent the normal interval, while the deviations show how readily the ear is satisfied by approximations when the intervals are non-harmonic.

Applying these results to the Balafong from Patna (given in my paper, p. 505), with the intervals 187 169 170 147 183 129 237 180 167 181 189 160 159 cents, and that from Singapore with intervals of 169 181 193 166 185 146 165 cents, and the Patala from Burmah (*ibid.* p. 506), with intervals of 176 174 183 174 192 154 193 cents, there seems to be very little doubt that these intervals also were intended to be *heptatones* of 171·43 cents each. This acknowledged equal division of the Octave into 7 parts greatly favours the hypothesis of the equal division into 5 parts in the Javese Salendro (*ibid.* p. 510, Nos. 11, 12, 13), but does not assist in explaining the Pelog scales (*ibid.* p. 513, bottom).

Like the Javese, the Siamese have no musical notation. All their music is learned by ear, and handed down traditionally, but not necessarily from father to son. The boys begin at a very early age. In England the Court Musicians have learned some English tunes, which they have been taught by hearing them played on a piano, and where semitones are required they take the nearest sound they have on their instruments. Of course the imitation of European music fails grievously where the Semitones are of importance, as in "God Save the Queen," which is, however, sufficiently recognisable to make the people stand up when it is played. Scotch pentatonic airs give better results; bagpipe tunes could be fairly enough rendered, on account of the neutral Thirds and Sixths.

For some of the preceding and most of the following particulars I am indebted to the kindness of Mr. Loftus, the interpreter to the Legation, who obtained them from the conductor in reply to a series of questions which I sent to him, and who has added to the obligations I owe him, by revising the proof of these remarks, which will thus furnish, so far as it goes, an authentic account of the Siamese music that has been listened to with interest by so many thousand people during the International Inventions and Music Exhibition of 1885 in London.

The pieces of music do not appear to have different names according to the notes which they begin or end. There are no scales corresponding to our major and minor, but the Ranat Ek is said to be of the higher and the Ranat T'hoom of the lower scale. Although there is no key-note, or tonic proper, there seems to be in every air a principal note called the Sieng Yeuns or main standing tone. The principal note changes, but the act of changing is called simply change. As a rule, however, the principal notes in all airs are alike, although exceptions are to be found. The tunes and airs are not named after their principal notes.* Airs are called Neur and variations upon them Kep. Sacred music is termed Sa-T'hu-Karn. Dance music has no collective name. Theatrical music is so called, in Siamese, Plang Lakorn. There are guild, and classes of musicians, but they do not prosper, as wealthy people keep their own musicians or bands, outsiders being seldom engaged on account of their bad performance. Children of musicians do not necessarily follow the occupation of their parents. There are no rules or customs in connection with the teaching of music, although children often learn from their parents. There is plenty of private music in Siam. Ranats are much used in private houses, and all the other instruments are also employed if the householder is wealthy enough to procure them. Excluding some very common but in no respect representative music given by holders of booths at feasts and shows, there are no public theatres or concerts in Siam, but the public is admitted to hear the music played in the houses of noblemen, and music is extremely popular. Almost every one is able to sing or play on some instrument. Women as well as men play on both the Mahoree, or "light-sounding" instruments, for indoor use, and the B'himb'hat, or "heavy-

* It is evident from the above that there are some interesting problems to be solved by Siamese music, but it would require much time, attention, and examination by competent musicians to arrive at the real theory. The above are slight indications of the existence of a tonic and modulation which would have to be very carefully pursued.

sounding" instruments, suitable for playing in the open air, and do almost all the singing both in ballads and operas. Women sing both singly and in chorus. Choruses have to sing strictly in unison, and no discanting is allowed, as with the leading Ranats. The singers have to keep strictly to the same notes and the same time. Religious singing is mostly done by men. Processional singing is also very popular. Comic singing and music is mostly to be heard in the theatres, although at feasts, &c., young men are fond of a comic song or a joke. None of the musicians now in England know of Siamese music having been written down. Siamese history also makes no mention of it. Of course European music in Siam is written, and Mr. Loftus says that a Siamese bandmaster, who is acquainted with European notes, has lately written down several Siamese airs, including the National Anthem, which have been revised by Signor Romano, in London, and are now in the press.* The rhythm is not very varied; 3 and 6 or 4 and 8 notes to the conductor's beat are the usual times employed.

SECTION XIII.—JAVA, p. 508.

In the Loan Collection (see Sect. IX. in this appendix) there were two Gambang Kajoe, or wooden harmonicons, purporting to come from Java. The first, with 18 bars, had the Octaves well tuned, but bar XV evidently did not belong to the scale. The scale was pentatonic, but certainly not Salendro, the only scale for which Sir Stamford Raffles gave pieces in musical notation, nor was it any of the six Pelog scales given on p. 512 of my paper. Mr. Hipkins and I measured bars VII to XII, and also the extra bar XV, but as the scale began on VI, I assume the Octave to be correct, and commence the scale with VI, thus:—

Vib.	249		280		338		379		455		498
Bars	VI	203	VII	328	VIII	196	IX	325	X	160	XI
Cents	0		203		531		727		1042		1202
Tempered	0		200		550		700		1050		1200

The conjectural tempered scale consists of a tone followed by two Fourths, each divided into a neutral Third, followed by a Threequarter Tone, but this is very unlike Javese music. The bar XV, of 849 vib., was quite inexplicable, but was nearly a just Fifth above bar XII, of 564 vib., the Octave of VII.

The other Gambang Kajoe had 17 bars, and was much smaller, but had also good Octaves. Bars I and II did not speak, and we measured from bar IV to bar IX. But assuming the Octaves to be correct, and beginning at bar V, we should get the following results:—

Vib.	323		364		396		491		529		646
Bars	V	206	VI	146	VII	373	VIII	130	IX	345	X
Cents	0		206		352		725		855		1200
Tempered	0		200		350		700		850		1200

which is similar to the last, only the division of the Fourth gives precedence to the Threequarter Tone. It is certainly very doubtful whether either of these scales now exists in Java.

There are two *Gendérs*, also metal harmonicons, but with resonance pipes. They were, however, both hopelessly out of order, and could not be got to act, so that we were obliged to omit them.

There were also seven Sárons, or heavy metal harmonicons. The bars in six of these were shaped alike and had good tones. The bars of the seventh were differently formed, like those of the Gendér, only larger, but their tone was so imperfect, that we could not measure them. The six others presented a very difficult problem. The bars being all nearly of the same length and width, had been put on in any order so that no one Sáron presented even the semblance of a scale. Mr. Hipkins and I first carefully measured the best of them, and then compared it with the others, marking Unisons and Octaves, and measuring all bars which were not so related to the first set. The result was that I made out seven different tones and their Octaves. It is not worth while going into details, but the following was the scale of seven notes, with the Octave of the first, omitting the other Octaves. The numbers I, II, &c. now no longer refer to bars, as these were scattered among different instruments, but to notes.

Vib.	124		140		158		167		189		202		222		248
Notes	I	210	II	209	III	96	IV	214	V	115	VI	163	VII	192	VIII
Cents	0		210		419		515		729		844		1007		1199

* The original MS. of these airs has been shown me. They bear the signatures of the keys F, C, G, which is of course a concession to European habits. The National Anthem is in F, and begins and ends on F. If played on a piano, these airs would possibly have to Siamese ears the same kind of imperfect effect that European airs have when played on Siamese instruments.

Although these do not agree with the seven Pelog notes on p. 512 of my paper, yet they must certainly be another version of a Pelog set of notes. But the instruments have evidently suffered by long keeping and transport, and the bars especially have been treated with little respect, as shown by the strange way in which they had been fitted into, or rather out of, their places. They cannot be relied on for showing a musical scale, and the wonder rather is that anything approaching to a real Sáron Pelog (p. 512) could have been deduced from such apparently inextricable confusion.

Section XV.—Japan, p. 520.

In my section on Japan, I felt obliged by testimony, to assume that the twelve Japanese Ritsu, or Semitones, were intentionally in equal temperament. Since reading my paper, Mr. Shuji Isawa, the Director of the Musical Institute at Tokio, Japan, has sent to the Japanese Department at the Inventions Exhibition a set of tuning forks, representing these 12 ritsu, another set of 8 representing the old and new style of tuning the Koto in Hiradioshi (p. 523, No. 1); a set of 4 forks showing the tuning of the Biwa in hiojo; and two sets of 12 reed pitch-pipes, one large and one small, giving the 12 ritsu, with the exception of the Octave, together with a new printed English edition of the extracts from his "Report on the Result of the Investigations concerning Music, undertaken by Order of the Department of Education, Tokio, Japan," with specimens of Koto music at the end. A duplicate of the 8 Hiradioshi forks was kindly sent to me personally. The forks were all accompanied by tables showing the theoretical scale, from which the forks themselves of course slightly differed. These forks and tables contain the most authentic account of the intentional and practical Japanese scale that we possess. The whole of the forks and reedpipes were passed over to me to determine the exact pitch of each, and, with the exception of the duplicate set presented to me, are now in the Exhibition, in the case with the Kotos. I gladly avail myself of this opportunity to give an account of the additional and more precise information thus obtained.

The report gives an outline of the history of Japanese music, by which it appears that Japanese music is entirely imported, and came from Korea, about 2,000 years ago, though the first recorded arrival of Korean musicians was A.D. 453, say 1,500 years ago. At the beginning of the 7th century, A.D., a Japanese ambassador was first sent to China, and the Chinese music of the Chinese Tau dynasty was introduced. As this dynasty declined at the end of the 9th century, Japanese subjects could no longer live safely in China, the embassy was recalled, and "not only was the progress of classical music interrupted, but the very existence of the art was in jeopardy. In Japan, classical music, which is more than 2,000 years old, remains much as it was at the time of its introduction; in fact, it has rather retrograded than otherwise, and is looked upon as unfit for further cultivation, and as valuable only as a relic of antiquity." Then attention was given to the works arising out of classical music, and popular music arose. Mr. Isawa considers that both classical and popular music are of Indian origin, and thinks that this theory is conformed by the resemblance of Japanese to Western scales. It is one of the objects of the Institute of Music at Tokio to raise the character of the present popular music, especially as regards the words, which are "altogether immoral in tone."

The names of the 12 ritsu are:—I Ichibotsu, II Tangin, III Hiojo, IV Shozetsu, V Shimomu, VI Sojo, VII Fusho, VIII Waushiki, IX Rankei, X Banshiki, XI Shinsen, XII Kamimu, after which the names recur. As these names are very long, and the symbols for them very complicated, the Japanese are introducing a series of numbers, of which the names and signs are more simple. Mr. Isawa identifies these names with an equally tempered chromatic scale beginning at D, and they are now so written on a European staff of five lines. But the tables sent with the forks show that they are obtained by a series of 11 perfect Fifths or Fourths, and then the Octave being taken perfect, the 12th Fifth is made a Pythagorean comma too close, and the Semitones are of course not equal, but alternately an apotome of 114 cents and a limma of 90 cents. But this theory is not followed by the tuner, as the pitches of the forks show, a quasi-temperament being used, which, being due entirely to feeling, is very imperfect. The pitches, however, show that the proper remedy is to use the French pitch in the Octave from D next above middle C, and I have prepared a set of forks preciseiy so tuned, to serve as a future standard for the Institute of Music at Tokio. The Tables in pp. 1109 and 1110 will make these remarks clear. The Pitch-numbers are the numbers of double vibrations made in one second.

If we examine the Fifths and Fourths tuned on the forks of the 12 Ritsu, by subtracting the cents, we shall find the real intervals as follows, the numbers representing the cents in the intervals between the notes on each side of them:—*D* 693 *A* 505 *E* 709 *B* 512 *F* sh 706 *C* sh 508 *G* sh 508 *D* sh 707 *A* sh (taken as *B* fl) 507 *F* 711 *C* 483 *G* 697 *D*. Each interval but the last should have been 702 or 498, and the last 678 cents. The major Thirds, which should all have been *F* 408 cents, are *D* 385 *F* sh 397 *A* sh; *E* fl 428 *G* 394 *B* 378 *d* sh; *E* 395 *G* sh 403 *B* sh; *F* 418 *A* 398 *C* sh; *A* fl 403 *C* 402 *E*. Hence, as compared with the ideal, all the Thirds are considerably wrong.

The Fifths and Fourths in the reed-pipes are *D* 705 *A* 500 *E* 708 *B* 505 *F* sh 719 *C* sh 518 *G* sh 491 *D* sh (taken as *E* fl) 701 *B* fl 498 *F* 713 *C* 509 *G* 675 *D*. Hence the reed pipes conform more accurately to the ideal than the tuning forks.

The Hiradioshi forks being in duplicate, we are able to test the accuracy of Japanese tuning. The theory of the old style was to have two tetrachords of

I.—The Twelve Japanese Ritsu.

i	ii	iii	iv	v	vi	vii	viii	ix	x
Notes, Numbers, and European Names.	Pitch numbers of the Japanese Forks.	Intervals in Cents. From note to note.	Intervals in Cents. From the lowest to the given note.	Theoretical Pitch numbers from tables.	Intervals in Cents. From note to note.	Intervals in Cents. From the lowest to the given note.	Pitch numbers of the Octaves below the larger reeds.	Intervals in cents from note to note.	French Pitch numbers for equal temperament.
XIII. *D*............	585·4	—	1201	585·4	—	1200	—		580·6
		110			90				
XII. *C*sh *D*fl......	549·5	—	1091	555·7	—	1110	560·6	—	548·0
		105			90			98	
XI. *C*............	517·3	—	986	527·5	—	1020	531·2	—	517·3
		89			114			121	
X. *B*............	491·5	—	897	493·9	—	906	495·2	—	488·3
		115			90			96	
IX. *A*sh *B*fl......	460·0	—	782	468·9	—	816	468·5	—	460·9
		89			114			114	
VIII. *A*............	437·0	—	693	439·1	—	702	438·6	—	435·0
		110			90			96	
VII. *G*sh *A*fl	410·1	—	583	416·7	—	612	415·0	—	410·6
		80			90			84	
VI. *G*............	391·5	—	503	395·6	—	522	395·4	—	387·6
		118			114			117	
V. *F*sh *G*fl......	365·7	—	385	370·5	—	408	369·5	—	365·8
		110			90			87	
IV. *F*............	343·1	—	275	351·7	—	318	351·3	—	345·3
		87			114			116	
III. *E*............	326·2	—	188	329·3	—	204	328·6	—	325·9
		113			90			87	
II. *D*sh *E*fl......	305·6	—	75	312·6	—	114	312·6	—	307·6
		75			114			118	
I. *D*........	292·7	—	0	292·7	—	0	292·1	—	290·3

Olympos, consisting of a diatonic Semitone of 112 cents and a just major Third of 386 cents, while in the new style they should have a limma of 90 cents and a Pythagorean major Third of 408. The following were the results. As the system is one for tuning the Koto of 13 strings, and as the scale is pentatonic, there are only six strings that need be noted, the remainder being Octaves above or below these. The pitches are here also contrasted with French pitch, which is of course nearer the new style than the old. Observe also that the Japanese forks have here only very nearly, not quite exactly the same pitch as the corresponding notes in the 12 Ritsu, but that the pitches of the Ritsu of course agree more closely for the new style.

It is thus seen that French pitch differs from that shown by the forks about as much as one set of forks differs from another, hence it could meet with no difficulties on the score of pitch. As to intervals, the Fifths and Fourths of equal temperament are so nearly perfect throughout, that it approaches the Japanese ideal far closer than the Japanese practice. All that seems to be wanted, therefore, is a trustworthily tuned set of forks, and with that I am happy to have been able to supply the Tokio Institute of Music.

In the *Mittheilungen der deutschen Gesellchaft für Natur und Völkerkunde Ostasiens* (Communications of the German Society for the Natural History and Ethnology of Eastern Asia; this Society meets at Tokio, Japan, but its communications can be had of Asher and Co., Unter den Linden No. 5, Berlin), parts 6, 8, and 9, for December, 1874, Sept. 1875, and March, 1876, Dr. Müller, physician to the Mikado, gives a long account of Japanese music with 24 large plates, figuring the instruments and their parts. At the beginning of this essay he says:—"If I had to describe the effect of European music on the Japanese, I think I should be right in saying that they find our music still more horrible than we find theirs. A Japanese gentleman said (of course not to me, they are too polite for anything of the kind, but nevertheless he did say): 'Children, coolies, and women are pleased with European music, but an educated Japanese cannot bear it.'" In a paper read before this German Society on the 20th September, 1884, of which a brief account is given in part 32 for May, 1885, Herr von Zedtwitz said: "Japanese

II.—The Two Sets of Hiradioshi Forks.

A. J. Ellis's set.					Exhibition set.			Equal Temperament.	
								French Pitch.	
No. of Koto string, and European name.	Pitch numbers of the Forks.	Intervals in Cents from note to note.	Intervals in Cents from lowest note.	Intervals in Cents in just intonation.	Pitch numbers of the Forks.	Intervals in Cents from note to note.	Intervals in Cents from lowest note.	Pitch numbers.	Intervals in Cents note to note.
Old Style.					*Old Style.*				
10 *d*	581·8	—	1197	1200	582·4	—	1197	580·6	—
		388				389			400
9 *B*fl.	464·9	—	809	814	465·1	—	808	460·9	—
		103				104			100
8 *A*	438·1	—	706	702	437·9	—	704	435·0	—
		204				201			200
7 *G*	389·4	—	502	498	389·9	—	503	387·6	—
		400				402			400
6 *E*fl.	309·0	—	102	112	309·0	—	101	307·6	—
		102				101			100
5 *D*	291·4	—	0	0	291·5	—	0	290·3	—
New Style. * Notes different from old style.				in Pythagorean intonation.	*New Style.*				from lowest note.
10 *d*	581·8	—	1200	1200	582·4	—	1199	580·6	1200
		407				409			
*9 *B*fl.	460·6	—	793	792	459·8	—	790	460·9	800
		85				85			
8 *A*	438·1	—	708	702	437·9	—	705	435·0	700
		204				201			
7 *G*	389·4	—	502	498	389·9	—	504	387·6	500
		417				420			
*6 *E*fl.	306·0	—	85	90	306·0	—	84	307·6	100
		85				84			
5 *D*	291·4	—	0	0	291·5	—	0	290·3	0

III.—Four Biwa Forks in Hiojo.

Forks.	Pitch numbers.	Interval in Cents note to note.	Interval in Cents from lowest.	French Pitch. Pitch numbers.	French Pitch. Cents note to note.	French Pitch. Cents from lowest.
a waushiki	436·7	—	1712	436·0	—	1700
		504			500	
e hiojo	326·4	—	1208	325·9	—	1200
		488			500	
B banshiki	246·3	—	720	244·15	—	700
		720			700	
E hiojo	162·9	—	0	162·95	—	0

music admits in general of no European harmonisation which entirely alters its character. To preserve that character, we can at most use Octaves, and from time to time introduce a Fourth or a Fifth. The Second occurs occasionally in Koto music, and it seems not to sound dissonant to Japanese ears. All Koto music is written in 4-4 time. The principal point is the rhythm which is often delicately worked out. Syncopated notes play a great part. The time is seldom varied within the same piece. But towards the conclusion of the piece there is often a *ritardando* which, as it were, prepares the player's bow as he finishes. If a composition consists of various movements, these often differ from each other in time, *Rokudan* is a good example. Each movement is played quicker than the preceding. Herr von Zedtwitz thinks the assertion occasionally made, that Europeans cannot enjoy Japanese music, to be unfounded. The pieces he presented and played to the Society were almost entirely melodious. The character of

Japanese music is serious and sentimental. Its real musical signification is most clearly proved by the majority of musical pieces seeming to demand harmonisation, and nothing is easier than to harmonise Japanese melodies. Any somewhat qualified amateur, whose ear has seized the spirit of Japanese music, can thus produce harmonious, characteristic, and interesting pieces. Only the Japanese themselves would generally fail to recognise their own music in this guise, because as has been said, harmonisation destroys its character."

ALEXANDER J. ELLIS.

28 Oct., 1885.

TELEPHONING FROM LIGHTSHIPS.

An experiment of the greatest importance to the commercial world is now being made on the East Coast of England by the Telegraph Construction and Maintenance Company. For the last eight months the company has had several of its best operatives located in the neighbourhood of the Naze, off which the most dangerous sands round England are to be found. These gentlemen are hourly in communication by telephone with a lightship which is anchored ten miles out in the vicinity of the Swin passage. An ordinary telegraph cable has been laid from Walton-on-the-Naze to the Sunk Lightship, and telephone and telegraphic apparatus have been affixed to both ends. It was considered improbable that the human voice would be conducted ten miles, especially in rough weather; but this has been now proved to be thoroughly practicable. A conversation was carried on with Mr Stevenson, one of the Telegraph Maintenance Company's officials (who was on board the Sunk Lightship), by telephone for a considerable time. Mr. Stevenson had been a month upon the boat, and had experienced all kinds of weather, during which time he had kept Mr. Lewis and Mr. Pinkerton, his colleagues on shore, fully informed of the state of the weather, roughness of the sea, and passing craft, adding frequently forecasts of weather which usually turned out to be correct. A month upon the lightship is a trying ordeal; but Mr. Stevenson was so satisfied with the success that attended the experiment, and knowing, if the advantage of telephonic communication with lightships was understood and generally adopted, what a splendid boon it would be to mariners and merchants, that he spent his time busily in collecting information, and watching the working of his electrical machines. In a back room of the Walton Post-office are machines for utilising magnetic currents of all descriptions. A button is touched which rings a bell in Mr. Stevenson's cabin upon the Sunk Lightship, ten miles away; then a voice, that of Mr. Stevenson—is heard inquiring what is wanted. "How is the wind?" "How is the tide?" "Have you seen such and such a ship pass?" "How much water is there in the Swin Passage?" These questions can be answered at once. Or the following is transmitted—"Signal such and such a ship that she is to put in at Harwich." Every ship passing is duly signalled, and her name and description telephoned to the Walton Post-office. On an average, ninety ships pass in the day, and if it was known that messages could be sent ashore, no doubt the majority of these would avail themselves of the benefit. A considerable number of the ships passing have come great distances without passing one of Lloyd's signalling stations. The signalling of these passing the Sunk Lightship would be of great commercial value, as their time of arrival at any port they were bound for could be timed by the owners in London accurately, and everything could be made ready for the landing and the sale of the cargo.

Of much more importance is the use the telephone could be put to in a storm or in the case of a ship getting on the sands. One night this year, in a rough sea, a ship did get on a sandbank, and instantly her exact position was telephoned to Walton from the lightship. The gentlemen at Walton awoke the lifeboat crew and telegraphed to Ramsgate and Harwich, where the lifeboats were got ready for launching. Just as all three lifeboats were about to start, a telephone message came from the lightship that the ship in distress had got safely off the sandbank, and that there was no need for the lifeboats to start. The boats were stopped, and if it had not been for the telephone they would have been out on the rough sea all night searching for the ship that sent up distress signals. If all the lightships around the coasts of Europe had this means of communication to point out the exact position of a ship in distress, a great number of lives would be saved, as the position of many ships foundering cannot be indicated with any certainty by the ordinary rocket signals. Besides the above uses of the telephone with lightships, all passing ships in quest of a pilot to navigate them through dangerous channels could without difficulty telephone their desires to shore. The Sunk Lightship is only 150 tons, and yet only once in the stormiest sea, when she had been tossed about in a gale of wind, has the telegraph wire been broken. The two ends at the break were picked up and rejoined within twenty-four hours. She is moored in ten fathoms of water, and is manned by a captain and six to eight men, all of whom express their most earnest approval of the intercommunication with the shore, whereby they can make known, at once, their own and the wants of others. During the night, communication is as open as in the day. The Trinity Board is showing considerable interest in the experiment, and it is hoped that it will see the great importance of at once putting, by this means, the chief lightships in communication with the shore. It is stated by the gentlemen engaged at Walton that the telephone will act over twice ten miles; and there is no reason why some day it should not act over much greater distances.—*The Times.*

General Notes.

SCIENCE IN JAPAN.—A correspondent at the Educational Museum, Tokio, Japan, announces that Mr. Twining's "Science made Easy" has been translated by an educational society into Japanese, for use in the schools of that country. The course, embracing physics, chemistry, natural history, and physiology, is illustrated with forty-three pictorial diagrams for school and lecture purposes.

NEW PROCESS OF DYEING BLACK.—The *Moniteur des Fils et Tissus* calls attention to a process of Messrs. Flottes and Lacombe, of Albi (Tarn), who claim to have discovered a new process (applicable to cotton, linen, hemp, jute, &c.,) for the production of a fast aniline black dye. The dyeing is said to be accomplished within one hour with a single bath. The labour is less than with other colours. The price is 4½d. per lb. The house referred to is said to be in a position to give information not only as to the above process, but likewise as to other fast colours on cotton, wool, silk yarn, &c.

SHIPBUILDING IN ITALY.—An iron steamer of 300 tons burden, will shortly be launched at Genoa, from the shipbuilding yard of Messrs. E. Cravero, marine engineers at La Foce. She has been built for a Genoese shipowner, Mr. A. Nain, who, since 1878, has established a regular packet service between Genoa and Rome. This vessel will be the largest that has hitherto ascended the Tiber as far as Ripa grande. A contract has been given by the Italian government to the same firm for building four sea-going torpedo boats. They are to be 40 metres (13·1 ft.) in length, and are to be delivered in eighteen months. The total cost will exceed £40,000.

TEXTILE INDUSTRY IN ROUMELIA.—The abundant water-power at the disposal of producers has done much to encourage the development of industry. The woollen industry is said, by the *Wochenshrift für Spinnerei und Weberei*, to be the most active. It not only employs all the raw material available in the country, but likewise imports largely from Bulgaria and Adrianople. The qualities of woollen cloth made are known as *Aba* and *Scheiak*, in addition to which fine flannel tissues are extensively manufactured in the Phillippopolis district.

ROPE RAILWAY AT BIELLA.—The project to connect the upper and lower parts of the town of Biella has received the sanction of the Minister of Public Works. The line, which will consist of a double track, will be 180 metres (590 ft.) in length, with a difference of level between the two extremities of 60 metres (196 ft. 8 in.), corresponding to a gradient of 1 in 33⅓. The gauge proposed is one metre, and the rails, which are to be of steel and of the Vignoles pattern, will weigh 36 kilogrammes per metre (72 lbs. per yard): they will be fixed on strong oak longitudinal sleepers, connected at distances of 4 metres apart (13 ft.) by iron tie rods, and the whole permanent way will be supported by brick pillars. The carriages (one for each line) will be capable of holding 12 passengers, and will be attached to the ends of a wire rope, passing over a horizontal pulley at the top end of the line, so that one car descends whilst the other ascends. Below the floor of the carriage will be a tank, divided into three compartments, two of which being of the capacity of 1 cubic metre, whilst the other will hold 1½ cubic metres of water, or in all 3½ tons in weight. The tank of the car being filled with water at the top of the line it descends by gravity, hauling up the other, the tank of which is empty. The speed will be regulated by a friction brake connected with the horizontal pulley passes, but the carriages will also be provided with powerful brakes, sufficient to bring them to a standstill on the incline in case the rope should break. The rope will be of steel, consisting of six strands of eight wires each, its diameter 23 millimetres (⅞ inch).

MEETINGS FOR THE ENSUING WEEK.

MONDAY, Nov. 2...Farmers' Club, Inns of Court Hotel, Holborn, W.C., 4 p.m. Mr. John Coleman, "Covered Yards."

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, Westminster Town-hall, S.W., 7½ p.m. Mr. J. B. Redman, "Tidal Approaches and Deep-water Entrances."

Chemical Industry (London Section), Burlington-house, W., 8 p.m. 1. Dr. C. R. A. Wright and Mr. C. Thompson, "Notes on the Chemistry of Soap." 2. Mr. V. H. Veley, "The Lime Process for the Production of Gas."

British Architects, 9, Conduit-street, W., 8 p.m. Opening Address of the Session by the President, Mr. E. Christian.

TUESDAY, Nov. 3...Biblical Archæology, 9, Conduit-street, W., 8 p.m.

WEDNESDAY, Nov. 4...Meteorological, 25, Great George-street, S.W., 7 p.m.

Geological, Burlington-house, W., 8 p.m. 1. Sir Richard Owen, "The Premaxillaries and Scalpriform Teeth of a large Extinct Wombat (*Phascolomys curvirostris*, Ow.)." 2. Prof. P. Martin Duncan, "The Structure and Classificatory Position of some Secondary Madreporaria." 3. Prof. P. Martin Duncan, "Some Points in the Morphology of the *Astrocœniæ* of the Sutton Stone in the Infra-Lias of South Wales."

THURSDAY, Nov. 5...Linnean, Burlington-house, W., 8 p.m. 1. Mr. John Ball, "Flora of the Peruvian Andes, and its History and Origin." 2. "Monograph of Recent Brachiopœda." (Part I.) By the late Dr. Thomas Davidson.

South London Photographic (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m. Demonstration by the Eastman Dry Plate Company of their Film Negatives.

FRIDAY, Nov. 6...Geologists' Association, University College, W.C., 8 p.m. W. Topley (President), "Carboniferous Rocks of Britain."

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FRIDAY, NOVEMBER 6, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ARRANGEMENTS FOR THE SESSION.

The First Meeting of the One Hundred and Thirty-second Session of the Society will be held on Wednesday, the 18th November, when the Opening Address will be delivered by SIR FREDERICK ABEL, C.B., D.C.L., LL.D., F.R.S., Chairman of the Council. Previous to Christmas there will be Four Ordinary Meetings, in addition to the Opening Meeting.

ORDINARY MEETINGS.

The following Papers (among others) will be read:—

"Apparatus for the Automatic Extinction of Fires." By PROF. SILVANUS P. THOMPSON.

"The Load Line of Ships." By Prof. FRANCIS ELGAR, LL.D., F.R.S.E., M.Inst.C.E.

"Technical Art Teaching." By F. EDWARD HULME, F.L.S., F.S.A.

"The Treatment of Sewage." By Dr. C. MEYMOTT TIDY.

"Calculating Machines." By C. V. BOYS.

"The History and Manufacture of Playing Cards." By GEORGE CLULOW.

"Domestic Electric Lighting." By W. H. PREECE, F.R.S.

"The Scientific Development of the Coal Tar Industry." By Prof. R. MELDOLA, F.C.S.

FOREIGN AND COLONIAL SECTION.

The Meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock:—

January 26; February 16; March 2, 23, April 13; May 18.

APPLIED CHEMISTRY AND PHYSICS SECTION.

The Meetings of this Section will take place on the following Thursday evenings, at Eight o'clock:—

January 28; February 11, 25; March 11; April 8; May 13.

INDIAN SECTION.

The Meetings of this Section will take place on the following Friday evenings, at Eight o'clock:

January 22; February 19; March 19; April 2; May 7, 21.

CANTOR LECTURES.

The First Course will be on "The Microscope." By JOHN MAYALL, Jun.

November 23, 30, December 7, 14, 21.

The Second Course will be on "Friction." By Prof. H. S. HELE SHAW.

January 18, 25; February 1, 8.

The Third Course will be on "Science Teaching." By Prof. F. GUTHRIE, F.R.S.

February 15, 22. March 1.

The Fourth Course will be on "Petroleum and its Products." By BOVERTON REDWOOD, F.C.S.

March 8, 15, 22, 29.

The Fifth Course will be on "The Arts of Tapestry Making and Embroidery." By ALAN S. COLE.

April 5, 12, 19.

The Sixth and Concluding Course will be on "Animal Mechanics." By B. W. RICHARDSON, M.A., M.D., F.R.S.

May 3, 10, 17, 24, 31.

JUVENILE LECTURES.

The Two Juvenile Lectures on "Waves" will be given by PROF. SILVANUS P. THOMPSON, D.Sc., on Wednesday evenings, December 30th, 1885, and January 6th, 1886. Special tickets will be issued for these lectures.

Proceedings of the Society.

CANTOR LECTURES.

THE MANUFACTURE OF TOILET SOAPS.

By C. R. ALDER WRIGHT, D.Sc., F.R.S., F.C.S.

Lecture III.—Delivered May 18, 1885.

IV.—MACHINERY AND APPLIANCES EMPLOYED IN THE MANUFACTURE OF BARS AND TABLETS.

(*a*) *Manufacture of Milled Soaps.*—It has long been known by perfumers and others working on a small scale, that by well pound-

ing in a mortar soaps made by the cold process, a thorough intermixture is effected, and in some cases a peculiar texture, or pearly scaly appearance, becomes developed. Of late years these operations, formerly carried out laboriously by hand labour, have been effected by machinery; and the result of successive improvements in this direction has been finally to develop a system of manufacture possessing a number of advantages, one of the most salient of which is that, being carried out without heating the soap to any marked extent, the most delicate flower essences, made by *enfleurage*, can be incorporated with soap in this way without deterioration of perfume, such as would inevitably result were these scents employed in connection with molten soap. Another advantage is, that the mechanical crushing and intermixing effected by a proper "mill" causes soap that has been artificially dried to some extent since manufacture to acquire a certain degree of plasticity, so as to enable it to be moulded into shape, somewhat as stale hardened glaziers' putty can be made plastic again by "working" it for some time; so that, in the end, the result is the production of tablets containing smaller amounts of moisture than those formed by remelting processes, and consequently not requiring any long exposure to warm air to dry and harden them before boxing for sale.

The manufacture of "milled" soaps is usually carried out by chipping up into shavings the bars of "stock" soaps used as basis, and subjecting the chippings to the drying action of a current of warm air for some hours, a series of latticed trays (or with perforated bottoms) being employed to hold the shavings, arranged vertically one above the other in a drying chamber, and sliding in grooves in the walls, so as to be readily inserted or withdrawn at pleasure. At the base of the chamber hot water or steam pipes run so as to create an upward current of warmed air passing through the masses of shavings piled up on the trays, fresh air being admitted at the bottom. Sometimes the chamber is fitted, not with steam or water pipes, but with a subsidiary heating vessel consisting of a convoluted steam pipe arranged inside a wider tube through which a current of air is made to pass, propelled by a blowing engine, a fan, or falling water, or aspirated through by connecting the upper part of the drying chamber with a chimney or steam draft.

The slicing up of the soap is usually effected by a machine, consisting of one or more blades, set like the cutting iron of a plane radially along a disc (precisely as in certain forms of household vegetable slicers). Sometimes all the soap is dried down to the required point; sometimes part is pretty thoroughly dried, and the rest used undried. The slicers are placed in a hopper, which gradually delivers them between two horizontal rollers nearly in contact (preferably of granite), arranged somewhat after the fashion of a large coffee mill; the gearing, however, is so arranged that one of these rollers (No. 2) rotates faster than the other (No. 1), so that the soap slices are not merely crushed in passing between the rollers, but are also subjected to a rubbing action. In consequence, the partially crushed material adheres by preference to the roller moving with greater speed (No. 2), and is carried along with that roller for a-half revolution or thereabouts, when it finds itself between roller No. 2 and another similar one (No. 3) moving still faster. In consequence, another crushing and rubbing action is set up (the distance between the rollers being suitably adjusted), and the material becomes transferred to No. 3 roller. Sometimes a fourth roller, moving still faster, is employed, and even a fifth on the same principle. Whatever the number of rollers, the film of thick doughy soap paste adhering to the last roller is scraped off by two sets of doctors with alternately placed scrapers, so as to deliver the scrapings into a box in the form of pasty ribbons some half-inch wide. These ribbons are then transferred back to the original hopper, and the intermixture and crushing repeated, colouring matter, scents, and other ingredients being added and intermixed *ad libitum* during the milling. Usually the materials pass three or four times successively, or even more often, through the mill before they are ground to a perfectly uniform paste; a certain amount of warmth is communicated to the mass by the friction and crushing, which heat must not be allowed to rise to too high an extent.

The ribbons finally obtained are next transferred to a machine, by means of which they are compressed and shaped into bars, which operation is known as "plotting" (*pelotage*). Two principal classes of machines are used for this purpose; one essentially consists of an engine cylinder filled with the ribbons, which are compressed by means of a hydraulic ram*, and finally "squirted" out through

* In the older forms of "cannon" machine, a powerful screw, worked by steam, is used to actuate the piston which compresses the ribbons into a solid mass, and ejects them as a compact bar.

a nozzle of such dimensions and shape as may be requisite to form a bar of the desired cross-section; much as lead and "compo" tubes for gas and water supply are manufactured, except that no cooling of the emerging mass is required. The other kind of machine is a modification of the well-known "pug-mill" used in the pottery manufacture, consisting of a powerful horizontal conical screw fitting pretty closely into a conical barrel, with a hopper at the top of the wider end. As the screw revolves, the ribbons fall down from the hopper and are caught in the thread of the screw, issuing under greatly increased pressure owing to the conicality. At the narrow end of the conical barrel the mass passes through a plate perforated with a large number of holes, so that it emerges therefrom as a number of parallel rods: the *vis a tergo* causes these to weld thoroughly together, and to pass through a tapering mouthpiece furnished at the exit end with a die, or stout metal plate perforated with an orifice of the dimensions of the cross-section of the bar ultimately required (*i.e.* round, oval, square, rectangular, or otherwise as desired). Finally, the bars are cut up transversely into blocks, which are stamped into tablets, and boxed for sale after a certain amount of standing, with exposure to air, to harden, and such dressing and polishing, &c., as may be required to give a nice "finish."

When required to produce a soap free from uncombined fixed alkali from stock soaps containing "free alkali," this may be effected in the mill, in accordance with the patented process referred to in a former lecture, by adding to the shavings, before their first passage through, an amount of an ammoniacal salt (such as the chloride or sulphate) equivalent to the average free alkali in the stock, preferably dissolved in as little warm water as possible. During the successive grindings, the ammonia and carbonate of ammonia formed during the neutralisation of the free alkali become practically all removed by evaporation, which readily takes place from the thin ribbons scraped off by the doctors.

(*b*) *Machinery and Appliances used in the preparation of tablets.*—The bars produced by the plotting machines above described simply want cutting into suitable lengths, and allowing to stand awhile, to be ready for the stamping operation which converts the pieces into tablets. For this purpose, machines are employed in which the block of soap (previously lubricated slightly with oil, glycerin, odourless petroleum, gum water, such as that made by adding water to "slippery elm," or other analogous substances) is compressed between a pair of dies, fitting within a ring or box, which determines the size of the tablet. A large variety of stamping machines for this purpose exist; in most, the impression is given by impact (as in stamping medals and coins), the dies being actuated by a lever, or combination of levers, a cam, a powerful screw, or other suitable mechanical arrangement, such that a considerable pressure is given for the instant, and intensified by the momentum of heavy moving parts. In some machines, the upper die is driven after the fashion of a pile driver; in others, a powerful pressure is developed by hydraulic agency. A succession of blows is sometimes desirable; sometimes the tablets are shaped by means of blank dies, and then dried awhile, and subsequently stamped again with the final dies, cut so as to give the proper impression. For light work, a press worked by the foot or hand suffices; for other kinds, stamps driven by steam power are required.

In the case of remelted soaps, and cold process or other varieties necessarily cast into blocks, the preparation of bars from the cooled blocks requires to be performed previously to cutting and stamping into tablets. The oldest and simplest method of procedure consists in drawing a thin wire, provided with handles at the ends, through the block horizontally, the operation being usually carried out by two men together, the exact line of cutting being previously marked out on the block; the slabs thus prepared are then cut up into bars, either in the same way, or by a hand machine carrying a wire, which slices off at each stroke a portion of the slab, forming a bar, the width of which is regulated by a gauge. A variety of slabbing and barring machines are in use for carrying out these operations more rapidly and effectively when large quantities have to be dealt with, as in the manufacture of household soaps; for the most part these consist of a travelling platform, on which the mass of soap rests, and by means of which the soap is propelled against one or more strained wires, so that, as the soap travels, the wires cut it into slabs or slices. In some machines, two sets of wires are used; one a series of parallel vertical wires, the other a similar series arranged horizontally, so that one motion of the travelling platform effects the division of a block into slabs, and also of each of these slabs into bars. These methods of cutting up ultimately result in the production of rectangular parallelopipeds of soap. To

convert these into tablets, they are exposed to slightly warmed air for a short time, so as to produce a surface-film of slightly dried soap, and thus avoid sticking to the dies when they are stamped. Tablets thus prepared are usually made from parallelopipeds smaller than the dies, so that the plastic mass is squeezed out and enlarged superficially (and correspondingly diminished in thickness) during stamping. A more or less strongly defined nearly square or oblong mark is apt to be thus produced, indicating the hardened edges of the small block, and to some extent disfiguring the tablet. To diminish and avoid this tendency, the parallelopipeds are often "dressed," or "shaped," by hand or otherwise, before stamping, so as to attain approximately the shape of the finished tablet, a kind of knife, or a "soap-plane," or a mechanical cutter, being employed for the purpose. The scraps thus produced, together with the ends of the bars and the outsides of the blocks cut off to trim them before slabbing, &c., often amount to a very considerable fraction of the block, especially when of comparatively small dimensions (*e.g.*, weighing only one, two, or three cwts.); thus, from 25 to 33 per cent. of the block, and sometimes more (if the block has shrunk irregularly in cooling, requiring a thicker outside slice to be removed in dressing), is usually reduced to scrap, which has to be utilised by re-melting, either by itself or along with the next batch of the same kind. This, of course, entails loss of labour and time, whilst perfume is lost by volatilisation, and frequently the soap is somewhat deteriorated, especially if the scrap has to lie by and harden for some time before being used up for another batch of the same colour and kind.

In order to avoid or diminish this waste, it has been frequently attempted to form the cast blocks into bars by compression, without cutting; but hitherto the processes suggested for this purpose do not seem to have come largely into use. One of the earliest methods proposed consisted in placing the block in the barrel of a kind of gigantic syringe, furnished with a piston, by means of which the mass of scrap is gradually forced out through a plate perforated with holes, each of which acts like the die-plate of the barring machines already described in connection with milled soaps, so that the soap emerges as a series of bars. Recently, further developments of this idea have been patented, a hydraulic ram being used to give the requisite pressure, and a special arrangement for the introduction of fresh soap after completion of the first stroke. With soaps sufficiently moist and plastic to "give" under pressure and weld together completely, machines of this sort can be employed to produce fairly compact bars; but many compositions used for toilet soaps crack and flake when thus treated, to such an extent that the bars ultimately formed cannot be worked up satisfactorily into tablets, inasmuch as, although the tablets formed look all right when finished, yet they are liable to break into pieces when used for washing hands, &c.

A recent patent of my own avoids this inconvenience, and also does away with the necessity of using moulds or frames for casting the soap into blocks, the molten soap being "squirted" directly into bars by means of a syringe-like arrangement propelling the soap through cooling tubes surrounded by water at a proper temperature, and finally through one or more moderately long final cooling and shaping tubes, furnished with nozzles at the far ends determining the dimensions of the cross-sections of the bars that emerge. When the temperatures of the cooling tubes, &c., are properly adjusted relatively to the nature of the soap operated upon and its speed of passage, perfectly formed sound bars are obtained of any required shape as regards cross-section (just as with the barring machines used for milled soaps). Practically, no loss by formation of cuttings and scrap is occasioned, whilst a considerable saving in time, labour, working space, and plant, is effected.

Instead of tablets, many persons prefer to use globular masses of soap, or "wash-balls." These are sometimes moulded by compressing a mass of plastic soap (previously roughly shaped by rolling between the hands, on a table, or between dished plates provided with handles) between hemispherical dies; but the better kinds are cut from a solid block and turned in a little machine (something like an apple-parer), provided with a curved planing iron which gradually cuts the mass to shape. Sometimes several successive parings, with alternate rests for drying, are requisite.

No matter what the shape of the stamped tablet may be, in many cases it is desirable to give an extra "finish" and polish to the surface by hand treatment, such as rubbing with a cloth or piece of felt moistened with spirit. In many cases exposure to wet steam for a few seconds develops on the surface a film or glaze of remelted soap, possessing an admirable gloss without any further manipulation being requisite.

I cannot conclude the discussion of this branch of the subject without expressing my thanks to Messrs. J. C. and J. Field, for supplying a large proportion of the numerous exhibits shown, illustrating the raw materials used in soap making, and the manufacture therefrom of the principal varieties of household and manufacturers' soaps; to Mr. R. Houchin for the loan of a number of the various machines constructed by him, and used to illustrate the various processes of cutting, shaping, and stamping soap tablets; also to Mr. F. A. Field for the preparation of a number of the diagrams of various kinds of plant and appliances too cumbrous to be actually brought into a lecture-room.

Valuation of Toilet Soaps by Chemical Analysis. Substances found in Toilet Soaps as Sold.

A certain portion of the cost of manufacture of a first-class toilet soap depends necessarily upon conditions as to which chemical analysis leads to but little distinct information, these circumstances more especially relating to the costliness of the perfumes used in scenting it, and the amount of labour bestowed in moulding and finishing it. But these circumstances have no necessary connection with the value of the soap *as such;* as regards the main characteristics of a thoroughly good soap, not only can these be satisfactorily ascertained during the course of analysis, but further, in no other way can the absence of objectionable constituents be completely proved.

The list of substances incorporated with various kinds of toilet soaps (partly as adulterants or "filling" intentionally added, partly as constituents intended to improve the article or to give it special qualities), together with the normal materials contained in such products, is a lengthy one, comprising amongst other things, the following:—

Alkalies. Potash, soda, and sometimes, but only rarely, ammonia, present in the form of actual soap; *i.e.*, alkalies combined with fatty or resinous acids.

"Free" alkalies: consisting of these substances present in a form capable of neutralising acids other than that of genuine soap, *i.e.*, alkaline matter not combined with fatty or resinous acids.

Neutral alkaline salts, more especially sulphates and chlorides (also including such semi-neutral salts as borax).

Fatty and resinous acids combined with alkalies forming actual soap.

Ditto present in the free state or as more or less imperfectly saponified glycerides.

Glycerin.

Glycerin "substitutes," *i.e.*, adulterants, more especially sugar.

Pigments and colouring matters.

Water.

Alcohol, volatile scents, essential oils, &c.

Organic materials added either to increase the bulk, or to communicate special qualities, such as powdered odorous roots and woods, farina, gelatin, dextrin, and gums of various kinds; oatmeal, bran, sawdust, and other vegetable matters; also beeswax, spermaceti, vaseline, ozokerite, petroleum, crude coal tar, and more or less purified coal tar distillates, including carbolic acid and creosote oils, and Stockholm and other vegetable tars.

Inorganic materials added for similar reasons, such as fine sand, infusorial earth, varieties of china clay and pipeclay, French chalk and fullers' earth, precipitated chalk, sulphur, and such like bodies.

For the complete analysis of soaps, including the quantitative determination of these and other constituents when present, various more or less successful methods have been propounded by different analysts, into the relative merits of which time will not permit me to enter; but I may point out that a considerable experience has led me to the conclusion that a very fair estimate of the general character and value of a toilet soap may be formed without quantitatively determining every possible constituent present, the data more especially requisite for deducing such conclusions being the following:—

Total alkali present, including—

Alkali combined as actual soap.

"Free" alkali, *i.e.*, alkali not so combined, but capable of neutralising acid.

Fatty matters present, including—

Fatty (and resinous) acids combined as actual soap.

Ditto, not so combined (free acids and unsaponified fats, &c.).

Glycerin (when present).

Together with qualitative tests as to the odour, melting point, and general properties of the fatty acids present; and similar tests (so performed as to give a rough idea of relative quantity) for poisonous metallic pigments (more especially compounds of mercury, as vermilion; copper and arsenic, as Scheele's green, and other analogous pigments; and

lead, as red lead and chrome lead), and for other matters insoluble in water (farina, French chalk, &c.), and for soluble matters, such as sugar and sodium chloride, &c.

Determination of Total Alkali, and of Fatty Acids formed on Decomposing the Soap.

For the estimation of the total alkali present, the ordinary volumetric processes are conveniently available, the most simple method being to dissolve a known weight of soap in hot distilled water, and gradually add to the solution standard acid, shaking or stirring vigorously after each addition, until all the soap is decomposed, and the fatty acids that swim up to the top in a fused condition retain no more alkali in the form of traces of intermixed or dissolved soap. I prefer cochineal as the indicator when working in this way, as artificial light does not notably interfere with the colour change when the acid is added until no further alteration in tint takes place (the acid being standardised with pure alkali in just the same way). A preferable modification is to add a measured quantity of acid—more than sufficient to neutralise all the alkali present—and shake or stir thoroughly; when the fatty acids have wholly separated, the excess of acid in the aqueous liquor is titrated.* The fatty matters thus separated may be collected and weighed with or without the addition of pure wax to give the cake of cooled fatty acids sufficient consistence to bear handling. Greater accuracy is usually supposed to be attained by dissolving the fatty acids in ether, or low-boiling petroleum-spirit, separating by a stopcock funnel, and evaporating off the solvent. My own experience, however, rather tends to the conclusion that this method is more troublesome, and about as likely to introduce errors as to eliminate them, on account of the difficulty in getting rid of traces of water when ether is used, and of higher-boiling petroleum constituents when petroleum ether is employed, these sources of error necessarily tending towards over-estimation.

In order to determine the amount of uncombined fatty acids or of unsaponified fat present, the soap may either be dried and powdered, and treated with ether or petroleum spirit, to dissolve out matters soluble therein, or may be dissolved in a minimum of water, and agitated with these solvents. The weight of matter thus extracted, when subtracted from the total fatty acids obtained as above, gives the quantity of fatty (and resinous) acids present combined as soap; the extracted matters, however, do not necessarily consist of fatty acids, or unsaponified fat, inasmuch as many fats and oils contain small quantities of constituents which can be thus separated from the soap made from them, but which are not themselves glycerides or fatty acids. Moreover, if beeswax, vaseline, ozokerite, or allied substances are contained in the soap (being added intentionally to give certain specific qualities), they will be thus dissolved out and separated; so that a further analytical examination of the extracted matters is necessary when they are present to any marked extent.

* When both soda and potash are present simultaneously, a quantitative determination of the latter must be made, from which, and the volumetric process, the former may be deduced.

Fixed Alkali.—Of all the *quantitative* analytical data obtainable on the examination of a toilet soap, by far the most important one is the determination of the "free alkali;" whilst the discrimination of the nature and character of the fatty matters employed in making the soap is of almost equal importance. Unfortunately, several methods are in use amongst analysts for the determination of "free alkali," which are not of equal trustworthiness, as they often differ considerably in their results. With a view of determining once for all which methods are to be preferred, and which are only misleading, I have (in conjunction with Mr. C. Thompson) made a searching comparative examination of these methods. The present occasion is not suitable for the complete discussion of all the results obtained, but the following brief synopsis of these results may be of interest, the detailed description being reserved for communication to another society.

The three principal methods in use may be conveniently distinguished as the *alcohol test*, the *fatty acid titration process*, and the *salting-out test*. The first of these consists in treating a known weight of soap (preferably dried previously) with strong alcohol, filtering hot, and titrating any caustic alkali in the filtrate, using phenol phthalein as indicator, whilst the residue left undissolved on the filter (consisting of carbonates, &c.) is dissolved in water, and also titrated, the sum of the alkalinities thus formed being reckoned as "free alkali." Besides being by far the most accurate process of the three, according to our experience, this method has the advantage of discriminating between that part of the free alkali which is present as *caustic* alkali, or hydroxide, and that part present as

other forms of alkaline matter, ordinarily far less violent in their corrosive action on the skin. For the purpose of toilet-soap examination, however, this distinction is not of paramount importance, inasmuch as only the very worst kinds of carelessly-made soaps contain free alkali in the state of hydroxide to any notable extent, although many soaps, even those prepared by makers of reputation, contain considerable amounts of carbonated alkali; in many cases this form of free alkali is intentionally introduced, either as carbonate of soda, to give hardening qualities, *i.e.*, to "close up" the soap, or as pearlash (carbonate of potash), to improve the texture—a most objectionable practice from the point of view of a consumer possessing a tender, sensitive skin.

The "fatty acid titration process" consists in determining the total alkali present in a known weight of soap, then separating the fatty and resinous acids therefrom and dissolving them in alcohol, and finally titrating the solution with alcoholic soda or potash solution, using phenol phthalein as indicator, the difference between the two titrations representing the "free alkali." Like all differential methods, the experimental error is large; so much so that, according to our experience, the possible error in such a determination may often exceed two or three per cent. of the amount of combined alkali, although the average of a number of determinations by this process is sensibly the same as the average of valuations of the same samples made by the alcohol test.* When the fatty acids of cocoanut oil, or other acids somewhat soluble in water, are contained in the soaps, an error of excess in the "free alkali" found may readily be brought about by incomplete collection of every trace of fatty acid owing to partial solubility. On account of the largeness of the probable error of this process, it is not to be recommended for the valuation of toilet soaps, in the better class of which the extreme limits of free alkali permissible do not exceed the amount possibly due to experimental error when this process of testing is employed; for household or laundry soaps, usually containing a considerable excess of alkali, it is sufficiently accurate to be of considerable practical use.

The "salting-out test" is even more apt to give fallacious indications: it is performed by dissolving a known weight of soap in water, and adding salt or saturated brine to the whole (or an aliquot part) of the solution, so as to throw out of solution a curd from which the aqueous liquid is separated by filtration; the alkalinity of this filtrate is then determined by standard acid, and reckoned as the "free alkali" contained in the soap. In thus operating, the sources of error are manifold, the tendency being almost invariably *to over estimate the free alkali*. Firstly, with certain kinds of soaps, notably those containing cocoanut oil acids, the addition of salt in quantity short of saturation may fail to throw out of solution all fatty acids as soaps, so that a small amount of soap remains dissolved. Secondly, even when this source of error is avoided (either by addition of a saturating amount of solid salt, or preferably by evaporation of the filtrate to dryness and taking up with just sufficient water to dissolve the saline matters, and filtering from flakes of soap thus rendered insoluble), another is usually introduced, due to the fact that solution in water more or less decomposes neutral soaps into acid ones and free alkali, so that the curd thrown out of solution retains somewhat less alkali combined with the fatty acids than corresponds with neutral soap, whilst the filtrate contains the balance, together with that originally present in the soap in excess of the neutralising amount. Thirdly, it is not practicable to introduce a satisfactory correction for the excess of alkali thus indicated by the "salting-out test," because not only does each kind of soap decompose to a different extent by treatment with a given quantity of water, but also the amount of decomposition (or *hydrolysis*, as it may be conveniently termed) is variable with the relative quantity of water used, increasing as the amount of water increases; further, the amount of hydrolysis effected by a given proportion of water acting on a soap made with a given kind of fatty acid is variable with the amount of alkali present in the "free" state in the original soap, so that whilst such a soap will, when neutral, become hydrolysed to a marked extent under given conditions, the hydrolysis may be greatly lessened or even stopped altogether by adding a small amount of free alkali to the solution before salting out. For all these reasons it is evident that the "salting-out test" cannot be recommended for the valuation of toilet soaps in which the presence of only minute quantities of free alkali is baneful, inasmuch as the possible error is far too great; but, like the "fatty acid titration pro-

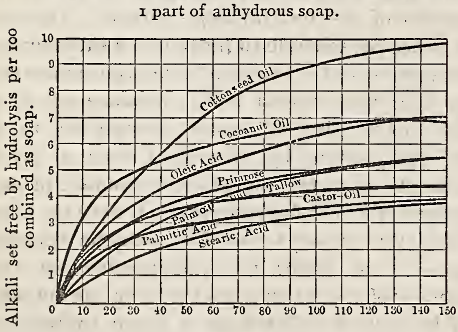
* In a series of check experiments, soaps of perfect neutrality were found, when examined by the fatty acid titration process, to indicate amounts of free alkali varying from + 2 or 3, or even more parts per 100 of alkali combined as soap to — values of about the same magnitude, the latter result apparently indicating excess of fatty acids

cess," this test is often of considerable practical value in the examination of the commoner kinds of soaps, more especially the strongly alkaline classes intended for scouring and general household purposes.

In connection with this point the following experimental results obtained by us may be quoted, being the average values deduced in a lengthy series of experiments on the amounts of hydrolysis effected when varying proportions of water are used to dissolve soda soaps made from fatty acids of the most frequently employed kinds. In all these experiments the soaps employed were either exactly neutral, or only faintly alkaline, so that no perceptible diminution in the amount of hydrolysis was occasioned by the presence of excess of alkali in the soaps. The numbers represent the quantities of alkali set free by treatment of one part by weight of anhydrous soap with m parts of water, calculated per 100 parts of alkali contained in the soap combined with fatty acids. The soaps employed were either prepared by ourselves or were obtained from manufacturers, with information as to the nature of the materials from which they were made, and subsequently analysed.

Soaps prepared from	Hydrolysis brought about by m parts of Water.					
	$m = 10$	$m = 15$	$m = 25$	$m = 50$	$m = 100$	$m = 150$
Pure stearic acid	0·75	1·0	1·5	2·4	3·4	3·8
Nearly pure palmitic acid	1·5	1·8	2·3	3·0	3·5	3·9
Crude lauric acid (cocoanut oil soap)	3·5	4·0	4·7	5·7	6·75	7·0
Pure oleic acid	2·1	2·6	3·5	4·75	6·3	7·1
Crude ricinoleic acid (castor oil soap)	1·75	2·25	2·75	3·6	4·3	4·6
Palmitic, stearic, and oleic acids, in nearly equal proportion (palm oil and tallow soap)	1·2	1·5	2·25	3·75	5·0	5·6
Tallow-resin soap (primrose)	1·7	2·2	2·9	4·0	5·0	5·6
Cottonseed oil soap	2·25	2·8	4·2	6·5	9·0	9·8

Hydrolysis brought about by m parts of water for 1 part of anhydrous soap.



Values of m.

The above diagram represents these values as curves, the values of m being abscissæ and the others ordinates. It hence appears that, with neutral soaps, the amount of hydrolysis brought about by using 10 parts of water to dissolve 1 of anhydrous soap may vary from 0·75 to 3·5; with 25 parts of water, from 1·5 to 4·7; with 100 parts, from 3·4 to 9·0, and so on, quantities ranging between far too wide limits to make it practicable to deduce any average values applicable generally as corrections to be applied to the results of the salting-out test. Further, the following values obtained with some of the above soaps, to which a small excess of alkali was added, show that the correction applicable to a neutral soap would be too large to apply to an alkaline one.

Soaps prepared from.	Extra alkali added per 100 combined as soap.	Hydrolysis brought about by m parts of water.		
		$m = 10$	$m = 15$	$m = 150$
Crude lauric acid (cocoanut oil soap...	11·0	1·0	1·5	1·8
Cottonseed oil soap...	15·0	nil.	nil.	6·9
Tallow - resin soap (primrose)...............	15·0	nil.	0·1	1·5
	20·0	nil.	nil.	nil.

A number of commercial toilet soaps were analysed, using simultaneously the alcohol test and the salting-out test, employing about 10 parts of water for 1 of anhydrous soap (from 5 to 9 parts for 1 of actual moist soap, according to its humidity). On the whole, it was found that in those soaps containing but little or no cocoanut oil acids, the two tests, when applied to soaps not containing more than 5 parts free alkali per 100 combined, usually differed by about 1·0 to 2·0, quantities fairly in

accordance with the hydrolysis values above described for this class of soaps, whilst, when large amounts of cocoanut oil acids were present, somewhat greater differences, usually about 2·0 to 3·0, were observed, again agreeing with the above higher values for the hydrolysis of cocoanut oil soap.

These experiments lead to one notable conclusion, viz., that the use of soaps absolutely devoid of free alkali in the solid state, or very nearly so, is not attended with quite so much advantage to the user as might at first sight be expected; for, when brought into contact with water, a certain amount of free alkali is generated, even were none present originally. Apart, however, from the fact that the alkali thus set free becomes more or less neutralised by acid matters naturally present adhering to the skin,* the cleansing effect of soap being largely due to this action, it is obvious that the alkali thus set free cannot be large in amount; the film of water adhering to the skin may perhaps weigh 10 or 20 times as much as the soap abraded from the tablet, and consequently with a toilet soap of good quality may possibly set free something like 2·0 per cent. of the alkali contained in this abraded soap. Taking this figure, it would result that four soaps containing respectively 0, 1·0, 2·0, and 3·0 of free alkali per 100 combined would develop lathers respectively containing 2·0, 3·0, 4·0, and 5·0 of free alkali; so that, in fine, whether a soap be absolutely neutral or contain a small amount of free alkali (not exceeding, say, 2 per cent. of the alkali combined as soap) is not a matter of such great consequence as it would at first sight appear. It is to be noticed, however, that practical experience leads persons possessing sensitive skins to eschew all soaps containing more free alkali than a very few per cents. of the amount present as soap, inasmuch as these alkaline soaps, when habitually used, cause a considerable amount of irritation and discomfort; whilst careful analysis shows, as will be more fully discussed later on, that the most highly esteemed skin soaps prepared by the best makers (which soaps do not by any means necessarily mean the most delicately-scented soaps prepared by perfumers, these being often objectionably alkaline) do not contain more free alkali than about one-fortieth part (2·5 per cent.) of the alkali present combined as soap.

Combined Alkali.—When the total alkali present in a given sample of soap has been determined, and the "free alkali" (by the alcohol test), the amount of alkali actually present as neutral soap is known, being the difference between the two amounts. The determination of this quantity, and of the amount of "fatty acids" yielded by the soap on treatment with acid as above described, leads to some valuable information concerning the quality of the soap, giving the means of calculating the actual per-centage of soap present (apart from water, &c.), and also furnishing some knowledge concerning the nature of the fatty matters used in making the soap.

The per-centage of actual soap present is not the same thing as the sum of the alkali contained as soap, and the fatty acids (corrected for unsaponified fat, &c.) as thus deduced, on account of the water taken up in decomposing the soap by the test acid. Supposing that A represents the per-centage of fatty acids, B that anhydrous soda (Na_2O) contained combined as soap, and C that of anhydrous potash (K_2O) similarly contained; then S, the per-centage of actual soap, is given by the equation:—

$$S = A + B + C - \tfrac{9}{31} B - \tfrac{9}{47} C$$
$$= A + \tfrac{22}{31} B + \tfrac{38}{47} C$$

If the soap be a pure soda soap, or if the amount of potash in it be but small, so that the total alkali may be reckoned as soda without material error, the value of the term $\tfrac{9}{31}$ B lies usually between ·030 × A and ·045 × A, according to the nature of the fatty acids, the smaller figure corresponding with acids of comparatively high molecular weight, such as arachidic acid ($C_{20}H_{40}O_2$), and stearic acid ($C_{18}H_{36}O_2$), and the latter with acids of low molecular weight, such as those of cocoanut oil (mean molecular weight near that indicated by $C_{12}H_{24}O_2$). As the former acids predominate in most opaque toilet soaps, the value ·035 A may be taken in most cases as sufficiently nearly exact for this class of soaps; whence

$$S = A - 0{\cdot}35\,A + B = 0{\cdot}965\,A + B$$

In the case of transparent soaps made without spirit, however, the proportion of cocoanut oil employed is usually sufficiently great to make $\tfrac{9}{31}$ B more nearly equal to 0·40 A, whence

$$S = A - 0{\cdot}04\,A + B = 0{\cdot}96\,A + B.^{*}$$

* A moistened blue litmus paper pressed on the skin is usually reddened by the action of perspiration-acids.

* Many analysts use the constant factor 0·97; this materially overstates the fatty anhydrides actually present. Thus, a pure cocoanut oil giving the values A = 50 B = 7·5 gives with this factor S = 5 ·25, whilst the true value is $S = A + \frac{22}{31} B = 55{\cdot}5$, or $\frac{0{\cdot}75}{55{\cdot}5}$ = 14 per mille lower.

From the per-centages of combined alkali and of fatty acids formed on decomposing the soap by a mineral acid, the mean molecular weight or combining number of the fatty acids is deducible; and the numerical value thus obtained, together with the melting point, sp. gr., and general characters of the fatty acids, often leads to information as to the nature of the fats and oils used in making the soap. If x be the mean combining number, A the per-centage of fatty acids present combined as soap, and B the per-centage of combined alkali expressed as anhydrous soda, Na_2O, then—

$$x = \frac{A}{B} \times 31.$$

The following table exhibits the values of x pertaining to various pure fatty acids and ordinary oils and fats, the latter being deduced from experiments in my own laboratory; very similar figures have also been obtained by other experimenters:—

Acid.	Formula.	Molecular weight.
Brassic	$C_{22}H_{42}O_2$	338
Arachidic	$C_{20}H_{40}O_2$	312
Ricinoleic	$C_{18}H_{34}O_3$	298
Stearic	$C_{18}H_{36}O_2$	284
Oleic	$C_{18}H_{34}O_2$	282
Palmitic	$C_{16}H_{32}O_2$	256
Lauric	$C_{12}H_{24}O_2$	200
Fatty acids from tallow, lard, olive oil	Chiefly $C_{18}H_{36}O_2$ and $C_{18}H_{34}O_2$	278 to 286
,, ,, ,, castor oil	Chiefly ricinoleic, $C_{18}H_{34}O_3$	293 ,, 299
,, ,, ,, cocoanut oil	Lauric acid $C_{12}H_{24}O_2$, with higher and lower homologues	196 ,, 204
,, ,, ,, palm oil mixed with tallow	$C_{18}H_{36}O_2$, $C_{18}H_{34}O_2$, and $C_{16}H_{32}O_2$	260 ,, 280

Soaps made from the class of fatty matters ordinarily used for the better classes of toilet soaps yield on decomposition fatty acids, the mean molecular weight of which is always above 256, generally above 275, and often above 280, when cocoanut oil is not one of the ingredients; when this oil is employed to any marked extent, the molecular weight is depressed in proportion to the quantity used. Opaque soaps of good quality rarely contain so much cocoanut oil as to reduce the mean molecular weight below 245 or 250; but transparent soaps made without alcohol generally contain so large a proportion of cocoanut oil as to give a mean molecular weight below 230, and often below 220.

The presence of large quantities of cocoanut oil in a toilet soap is, in England, generally considered objectionable, partly on account of the fact that unless certain special methods are adopted in the treatment of this oil, the soaps made from it are apt to possess an unpleasant odour, which is communicated (often in an intensified form) to the skin or to articles washed therewith; partly because cocoanut oil requires a somewhat different strength of alkaline ley to effect saponification from that requisite for boiled curd soaps, and in consequence is generally made strongly alkaline; and partly because cocoanut oil soap possesses to a greater extent than almost any other the property of giving a fairly hard mass even when large quantities of water are present, provided that a certain proportion of saline matters are introduced to "close up" the mass; so that perfumers and others using cocoanut oil soaps as an ingredient in a blended mass prepared by milling or remelting, often turn out a finished product containing an undue proportion of free alkali or saline matters. Most of these objections, however, do not necessarily apply to an article made with due attention to certain details in the preparation (the knowledge of which, however, does not appear to be possessed by every maker); accordingly a certain proportion of cocoanut oil is often to be found in some of the highest class of Parisian soaps, a ready capability of lathering and other advantages being gained by its presence without any marked counterbalancing disadvantages, as long as the necessary precautions to avoid them are taken.

Determination of Glycerin.—The accurate determination of the quantity of glycerin present in a sample of soap is not always easy, especially when sugar is also present. The method usually prescribed is to dissolve

a known weight of soap in water, acidulate (preferably with sulphuric acid), filter from separated fatty acids, neutralise with carbonate of soda, evaporate to dryness, and treat the residue with strong alcohol, which dissolves glycerin and leaves behind sodium salts. The residue left on evaporation to dryness of the alcoholic solution is rarely pure, most soaps containing small quantities of substances derived from the original oils and fats which are not insoluble in the acidified aqueous fluid, and thus become more or less dissolved out by the alcohol, so that soaps containing no trace of glycerin will still furnish small per-centages of alcoholic extract when thus treated. Chloride of sodium, too, being slightly soluble in ordinary alcohol, may be contained in the extract. By redissolving the dried extract in absolute alcohol and adding one and a-half times its volume of ether, a certain amount of substances other than glycerin is generally precipitated; but in most cases even this purification fails to yield pure glycerin, especially in presence of sugar. A fairly accurate valuation of the amount of glycerin present in the extract may be obtained by rendering it strongly alkaline with aqueous caustic soda, and then dropping in dilute copper sulphate solution with agitation, until the copper hydroxide thus formed begins to fail to dissolve; the filtered blue solution is compared colorimetrically with a known quantity of a standard solution of glycerin treated side by side in the same way. When sugar is present, the alcoholic extract must be treated with dilute sulphuric or other acid for some time, so as to "invert" the sugar, the fluid being then rendered alkaline, and copper sulphate dropped in boiling as long as suboxide of copper is reduced, after which the colorimetric estimation of the glycerin is proceeded with as before, the comparison being preferably made with a known solution of glycerin and cane sugar treated side by side with the sample tested. With care and practice fairly good results can be thus obtained, more especially when sugar is absent. The following figures illustrate the numbers obtained in analyses for glycerin, the values being percentages:—

Nature of Soap Examined.	Crude alcoholic extract.	Extract purified by ether.	Glycerin indicated by copper test.
An opaque untinted soap of moderate quality	7·0	6·1	6·0
A higher class Parisian soap sold as a glycerin soap, not transparent	8·1	7·9	8·0
A cold process soap containing much unsaponified fat	6·6	4·9	4·75
A British so-called "glycerin" soap; opaque	7·9	7·9	0·6
Another, ditto	7·7	6·7	0·4
Another, ditto	0·75	0·43	nil.
A British transparent soap, not containing sugar	19·0	17·6	15·0
Another ditto, containing upwards of 10 per cent. of sugar	6·1	4·0	nil.

The entire absence of glycerin from a toilet soap necessarily proves that the whole mass has been prepared either by a boiling process or by saturating a free fatty acid (*e.g.*, oleic acid) with alkali, or by both processes combined, whilst, on the other hand, the presence of a quantity not far removed from the per-centage of combined alkali (expressed as Na_2O) suggests that the whole has been probably prepared by a cold process; for as ordinarily oils and fats are substantially triglycerides, one equivalent of fatty matter will yield 92 parts of glycerin and fatty acids, equivalent to 93 of Na_2O.* When larger quantities of glycerin are present, extra glycerin must have been added to the materials during manufacture; when small quantities only are present, constituting only a fraction of the per-centage of combined alkali (expressed as Na_2O), the soap is probably a blended mass, consisting partly of boiled and partly of cold process soaps.

Classification of Toilet Soaps in Accordance with the Results of Chemical Analysis.

It has already been repeatedly noticed that the prevailing fault of a very large proportion of British toilet and fancy soaps is that they contain such quantities of "free alkali" as to render them decidedly injurious to tender and sensitive skins when habitually used. Although the general public has not as yet been thoroughly "educated up" to the point of appreciating the magnitude of this evil, yet most persons whose skins are extremely sensitive find by experience, in winter or during the prevalence of easterly winds, that frequent washing with soap and water is impossible

* In actual practice the quantity of glycerin yielded by oils and fats usually falls a little short of that corresponding with a triglyceride, usually 85 to 90 per cent. of that amount, according to my own observations; similar deficiencies appear to have been also noticed by other chemists.

without producing much personal discomfort, unless they use selected kinds of soap to which experience has guided them. Many such persons discard soap altogether in favour of materials like oatmeal, and certain vegetable creams and other cosmetics which do not contain alkaline matters.

As regards the injurious effects of soaps containing free alkali on persons possessing sensitive skins, there is a general consensus of opinion amongst those hygienists and specialists in skin diseases who have carefully studied the matter, that such is actually the case to a far greater extent than is suspected by the general public. As representing such opinions, the following remarks may be quoted, by Mr. J. L. Milton, senior surgeon to St. John's Hospital for Diseases of the Skin:—"Most toilet soaps . . . . contain too much alkali, not, perhaps, an object of much importance to persons with hard, strong skins, but of great consequence when this organ is sensitive or out of order; and we constantly have cases of relapse at the hospital from the use of alkaline soaps for domestic purposes." Plenty of other medical testimony to the same general effect might be also quoted did time permit.

In view of the objectionable effects produced by excess of alkalinity in toilet soap, and of the circumstance that the best British and foreign makes are found by analysis to contain only very small quantities of free alkali, expressed as anhydrous soda, Na_2O, not exceeding 0·20 to 0·25 per cent. by weight (the combined alkali being usually about 7 to 9 per cent., or some forty times as much), I am disposed to classify toilet soaps into three grades, from the point of view of the amount of free alkali present, viz.:—

First Grade.—Soaps which are, if not actually neutral, at any rate so far devoid of free alkali that the amount of total alkaline matter present in forms other than actual soap does not exceed $\frac{1}{40}$th part (2·5 per 100) of the alkali present, combined with fatty acids as soap.

Second Grade.—Soaps in which the free alkali, although exceeding $\frac{1}{40}$th part (2·5 per 100) of that combined as soap, does not overpass $\frac{3}{40}$th of that amount (7·5 per 100).

Third Grade.—Soaps in which the free alkali exceeds $\frac{3}{40}$th (7·5 per 100) of the alkali combined as true soap.

The chief reason for drawing the line of demarcation between second and third class soaps (as regards free alkalinity) at the point named, viz., $\frac{3}{40}$th of the combined alkali, is, that during the last few years I have noticed, in members of my own family and friends possessing sensitive skins, that the use for a short time of a toilet soap containing sufficient free alkali to bring it into the third grade as thus defined, has almost invariably caused a considerable amount of inconvenience and discomfort, even when the nature of the fatty acids present was not in any way objectionable. Of course, however, the precise position of the boundary line is open to discussion, and the fixing it at the point named is a matter of personal opinion. I believe, however, that in practice the above figures will be found to represent fair standards of character.

As regards the third grade of soaps as thus defined, it is noticeable that it includes, not only nearly all the transparent soaps made without alcohol that have come under my notice (probably on account of the use of excess of caustic alkali in the first instance, to ensure complete saponification and transparency, or the addition of soda crystals as a hardening and "closing up" agent), but also a not inconsiderable number of soaps made by perfumers (probably by the cold process), and usually deliciously scented, and in consequence sold at prices that might be expected to be a guarantee of high quality; so that high price alone is by no means necessarily a criterion of excellence, although it is certainly true that no article can possibly be made at a low price, combining simultaneously the various requisites of choiceness of materials, freedom from alkalinity, elegance of finish, and delicacy of perfume.

It is obvious that it does not follow that a soap is of high quality as a toilet soap simply because it is practically free from excess of alkali, although the converse is true, viz., that a soap is entirely unsuited for application to the skin when it contains much of that constituent, no matter how excellent it may be in other respects. In short, a toilet soap, to be of the first class from all points of view, must possess the following qualities. First and foremost, it must contain practically no free alkali; secondly, it must be made from materials free from all trace of rankness, coarseness, or rancidity, *i.e.*, the fatty matters and oils, &c., used in its preparation must be of best quality carefully selected; further, it should not be liable to discolour or brown to any great extent on keeping; for this change of colour is accompanied by oxidation (as evidenced by the fact that the discoloration commences

from the outside by contact with air) the effect of which is sometimes to produce a change in the soap akin to that termed rancidity in an oil, accompanied by the development of an unpleasant odour; soaps which have undergone this change occasionally acquire the power of injuriously affecting sensitive skins, causing blotching and irritation, even though free from excess of alkali to any marked extent.* Again, to be of high quality, a toilet soap cannot contain large per-centages of water; for this entails the use of saline matters to "close up" and harden the mass, and these, if present in any quantity, are not unlikely to affect the skin injuriously. Further, if tinted, or "medicated" by intermixture with non-saponaceous matters, such as thymol, vaseline, sulphur, &c., the soap must not contain any compounds capable of causing irritation, and especially should be free from poisonous metals, and notably from mercury, lead, copper, and arsenic; whilst, to give satisfaction to purchasers, it must not be liable to melt away rapidly even in hot water, and must lather freely, giving a bland emollient feel during use. Unless a soap can pass all these tests satisfactorily it cannot be regarded as a first-class article; if defective in one or more vital points, it can only be assessed as second-class; and if defective in many, as third-class.

General Character of Toilet Soaps as Sold in England.

The number of soaps sold in this country that can be classified in the first rank, in accordance with above system of requirements, is very small as compared with those that fall into the second and third classes, so far as a somewhat wide analytical experience of them enables me to judge; thus the Tables in pp. 1126, 1127, 1128, contain the results of the analyses of a few specimens of British manufacture, selected from a much larger number as typical examples; for obvious reasons, the trade-marks and makers' names are not stated. A certain number of soaps of Continental origin are also included in the tables. The figures representing the "retail price per pound of actual soap" are instructive; they are arrived at in the following way. The average weight of tablets, as sold to purchasers, being determined, the retail price being known, and the per-centage of actual soap present (apart from water, saline matters, &c., also contained) being known by analysis, the price is calculated by the formula:—

$$x = \frac{16}{w}\,\frac{100}{s}\,d = 1600\,\frac{d}{ws}$$

where x = "retail price per pound of actual soap," in pence.

w = average weight, in ounces, of tablet as sold.

s = per-centage of actual soap.

d = retail price per tablet, as sold, in pence.

Thus suppose the soap to be sold in eighteen-penny boxes of three tablets, *i.e.*, let $d = 6$; let each tablet weigh on an average 3·2 ounces (or five tablets to the pound); and let the soap contain 75 per cent. of actual soap; then—

$$x = 1600\,\frac{6}{75 \times 3{\cdot}2} = 40$$

so that the retail price per pound of actual soap is 40 pence, or 3s. 4d.

The amounts of "free alkali" stated in these tables are uniformly reckoned per 100 parts of alkali actually combined as soap, so that according as these amounts fall below 2·5, between 2·5 and 7·5, or above 7·5, the soap would be classed as of the first, second, or third grade respectively, if judged solely by the criterion of free alkalinity. The "classification" given in the tables, however, is not based solely on this criterion, but on this conjointly with the character of the soap as a whole, and its freedom or otherwise from adulterants, "filling," and water and "closing up" agents, and from poisonous colouring matters; and also with the nature and quality of the fatty matters used as basis, their freedom from rancidity either before making into soap, or subsequently, and so on. No great stress is laid on the delicacy or character of the perfume, nor on the perfection of finish of the tablets, in classifying the soaps, because, although these points affect the price to some extent through entailing a greater amount of labour or a greater cost for perfume, they have no real connection with the intrinsic qualities of the soap as such.

* It seems very probable that this browning and decomposing action is due to the presence of small amounts of nitrogenous matter; it is often noticed in soaps made from tallow, especially of inferior grades, and in fact is so marked as to be one leading cause why toilet soaps are usually tinted red, brown, or orange, in preference to blue, mauve, or green, the latter colours becoming far more muddy and dirty looking on keeping than the former, owing to the spontaneous browning of the soap itself.

Taking into consideration not merely these but also all the other numerous analyses made, I have arrived at the following conclusions, as regards the general nature of the various toilet soaps sold in this country.

(1) *As regards Opaque Soaps.*—A limited proportion of excellent soaps are to be had, containing not more free alkali than corresponds to one-fortieth part of the combined alkali, and made from good sound materials in the way of fatty matter, &c., serving as basis. In these soaps the per-centage of actual soap present ordinarily varies from 70 to 90, according to the mode of manufacture, and to the amount of other non-saponaceous matter added for special reasons (*e.g.*, glycerin) the per-centage of water usually ranging from 6 or 7 to 20, and sometimes slightly exceeding the latter amount. The retail price of these soaps, reckoned per pound of actual soap, varies from

Opaque Toilet Soaps.—Untinted.

British.

Free alkali.	Per-centage of actual soap	Retail price of actual soap per lb.	Remarks.	Classification based on general characters, amount of free alkali, and nature of fatty acids.
		s. d,		
6·6	73	0 11	Tallow curd with a little cocoanut oil. Turned brownish on keeping a few weeks. Odour not very rank, but distinctly tallowy.	III.
2·3	79	1 0	Much the same general charaeters as the preceding, but more marked tallowy odour.	III.
6·0	84	2 2	Faintly perfumed; contained some cocoanut oil, but without objectionable odour in use.	II.
10·5	71	3 4	Contained several per cents. of oatmeal: nicely scented, but objectionably alkaline. A perfumers' soap of fairly typical quality.	III.
20·8	70	3 4	Contained 8 per cent. of French chalk. Most objectionably alkaline, yet advertised as a specially pure skin soap.	III.
13·0	70	3 5	A British perfumers' soap, delicately scented, but turning brownish on keeping. Objectionable excess of alkali.	III.

Cheaper Class of Opaque Toilet Soaps.—Tinted.

British.

Free alkali.	Per-centage of actual soap.	Retail price of actual soap per lb.	Remarks.	Classification.
		s. d.		
7·0	76	1 3	Tinted yellow with soluble organic colouring matter; largely made of cocoanut oil, but possessing no marked rank odour. Somewhat alkaline.	II.
5·9	81	1 6	Sold as "Glycerin" soap, but absolutely devoid of glycerin. Resinous odour. Tinted yellow with organic colouring matter. An inferior kind of resin soap.	II.
8·5	78	1 7	Moderately good curd soap, but too alkaline. Chiefly tallow with a little cocoanut oil. Tinted red with mercurial sulphide.	III.
33·5	73	2 2	So-called "Brown Windsor" tinted with burnt umber. Highly alkaline.	III.
6·0	64	2 5	So-called "Glycerin," but only containing ·4 per cent. of glycerin. Tinted dull orange with organic colour. Agreeably scented.	II.

Superior Class of Opaque Toilet Soaps.—Tinted.

Free alkali.	Per-centage of actual soap.	Retail price of actual soap per lb.	Remarks.	Classification.
		s. d.	British.	
Nil	83	2 9	Tinted orange with soluble organic colouring matter; pleasantly scented. The cheapest of all the soaps examined that could fairly be called first-class.	I.
6·5	78	2 11	Tinted green with a mixture of ultramarine and yellow soluble colouring matter; agreeably scented. Became very dingy-coloured on keeping.	II.
7·6	67	3 3	Tinted with chlorophyll, the colour fading speedily on keeping. Pleasantly scented, but notably alkaline.	III.
1·0	85	4 3	Tinted pink with mercurial sulphide. Delicately scented rose.	II. almost I.
			Continental.	
Nil	84	3 0	Tinted pink with organic colouring matter. Pleasantly scented rose.	I.
1·5	92	4 10	Tinted dull pink with mercurial sulphide. Deliciously scented.	II. almost I.

True Glycerin Soaps not adulterated with Sugar.

	Free alkali.	Per-centage of actual soap.	Per-centage of glycerin.	Retail price of actual soap per lb.	Remarks.	Classification.
				s. d.	British.	
Opaque.	9·0	74	6·0	1 3	Nearly white, slightly rank odour, unscented; largely made from cocoanut oil. Objectionably alkaline.	III.
					Continental.	
Opaque.	1·3	55	4·9	3 10	White: contained 16·5 per cent. of unsaponified fat. Mostly cocoanut oil, but no marked rank odour. Wastes rapidly in hot water.	II.
Opaque.	Nil	74	7·9	5 3	Tinted mauve with organic colouring matter. Delicately scented.	I.
					British.	
Transparent.	1·5	60	14·3	6 5	Made with pure alcohol (not methylated spirit). Slightly scented. Wastes rather rapidly in hot water.	I.
Transparent.	7·0	26	17·6	9 7	Supposed to contain half its weight of glycerin. Very wasteful in use, melting completely in hot water.	II.
					Continental.	
Transparent.	1·6	33	35·0	7 6	Pleasantly scented, but very wasteful in use. Melts completely in hot water.	I.

Transparent Soaps containing Sugar.

Made with Spirit.

Free alkali.	Per-centage of actual soap.	Per-centage of sugar.	Retail price of actual soap per lb.	Remarks.	Classification.
			s. d.		
Nil.	70	10	4 8	Made with methylated spirit, and possessing in consequence an unpleasant odour only imperfectly disguised by perfume. The cheaper soap sold as containing 30 per cent. of glycerin, but actually containing none at all.	II.
Nil.	68	10	18 0		
8·5	52	26	2 2	Made with methylated spirit; objectionably alkaline.	III.
				Made without Spirit.	
			s. d.		
20·8	52	18	2 6	Fairly representative specimens of different kinds of transparent soaps not made by solution in spirit. Largely prepared with cocoanut oil, and generally strongly scented to disguise rank odour. Largely mixed with sugar, and in consequence very wasteful in use, rapidly dissolving in hot water. Always most objectionably alkaline.	Low down in Class III.
19·0	48	28	5 10		
25·8	45	22	2 6		

two shillings and ninepence to eight or ten shillings; these figures correspond with from fourpenny tablets of about six to the pound, containing 70 to 75 per cent. of actual soap (or sixpenny tablets of four to the pound, containing about the same per-centage), to eighteenpenny or two shilling tablets, of about 3 or 3½ ounces in weight, and containing 85 to 90 per cent. of actual soap.

By far the majority, however, fail to attain such excellence as to entitle them to be placed in the first class, excessive alkalinity being the most conspicuous fault. A considerable number of soaps sold at sixpence and upwards per tablet are excluded from the first class, and some even ranked only as third class soaps, solely from this cause. Similarly, numerous soaps, the retail prices of which lie between two and three shillings per pound (tablets sold retail at threepence and fourpence) have to be placed in the third instead of in the second class, solely for this cause. A few cheap soaps (twopenny tablets) are sufficiently good to be ranked in the second class, or very close to it; but the majority of tablets retailed at prices representing tenpence to eighteenpence a pound (penny and twopenny tablets) are utterly unworthy to be termed toilet soaps at all, being usually made from more or less coarse or rank materials, often with a large excess of alkali, and generally containing considerably upwards of 25 per cent. of water, with large amounts of sulphate of soda or other saline matters to "close up" and harden the mass. Such tablets, when kept for some time in a dry place, usually become more or less incrusted with saline efflorescence, losing their shape as they dry.

Tinted soaps, whether of high or low price, are very frequently coloured with pigments containing poisonous metals, mercury (as vermilion) and lead (as red lead) being not unfrequently to be found therein, and sometimes arsenic and copper.

A very considerable fraction of the cheaper soaps sold as "Brown Windsor," owe at least a portion of their colour to alteration and oxidation of the soap, either during manufacture or subsequently, inasmuch as there is reason to believe that this change is occasionally accompanied by the development of a tendency to irritate sensitive skins; such soaps, as also those tinted originally with pretty colours that have become dull and dingy on keeping, should be avoided.

(2) *As Regards Transparent Soaps.*—Almost all the transparent soaps made by cold processes (often sold as "glycerin soap") that I have met with contain large amounts of free alkali, exceeding 10, and sometimes exceeding 25, per cent. of the alkali present combined as soap; they rarely contain more than half their weight of actual soap, the remainder being chiefly water, sugar, and salts added to

"close up" and harden the mass (carbonate of soda thus added being a source of much of the excessive alkalinity). The low per-centage of actual soap and the high per-centage of sugar (often 20 to 25 per cent., and even more) render this class of soap not only very wasteful in use, from the easy solubility (some kinds actually *melting* in hot water), but also much more deleterious to tender skins than soaps not containing sugar and of high per-centage in actual soap, because much more alkali is brought into contact with the skin in use owing to the more rapid solution; apart from the larger amount of free alkali present, and also from the fact that these soaps consist largely of cocoanut oil soap, which hydrolyses more rapidly in contact with water than most other kinds. Notwithstanding their defects from a chemical point of view, these soaps have of late years come largely in demand, mainly on account of their attractive appearance; they cannot, however, be termed economical, as the price, when reckoned per pound of *actual soap*, is somewhat high with the better kinds, owing to the low per-centage of soap present (fourpenny tablets of five to the pound, and containing 45 per cent. of actual soap, represent three shillings and eightpence *per pound of actual soap*), whilst lower-priced kinds, costing two shillings to two shillings and sixpence per pound of actual soap (twopenny and threepenny tablets), are often made from materials so coarse and rank as to leave a most disagreeable odour on the skin after use, not at all perfectly disguised even by the addition of strongly-scented essential oils, &c., in large quantity. In fact, the cheaper classes of transparent soaps, made without spirit, are, as a rule, decidedly the worst value for the money of any in the market, being very far inferior in quality to many household soaps costing much less than half the price.*

On the other hand, transparent soaps made by dissolving stock soaps in boiling spirit are, as they are actually sold, by no means always as good as they might be, although they generally (but not invariably) have the merit of being very nearly neutral. Some few are to be bought made with pure alcohol (not methylated spirit) from stock soaps of thoroughly good quality, the transparency being aided by the addition of some 10 to 15 per cent. of glycerin; and these are of the very first rank as soaps: but far the largest proportion of this kind of soap sold consists of stock soaps (often of inferior grades) rendered transparent by means of methylated spirit, sugar being also substituted for glycerin; and the experience of several of my own friends and members of my own family in connection with this kind of make is, that the use for a short time of such a soap is liable to bring about blotching and irritation of the skin to a very marked extent. Whether this is due to rankness of the fatty matters used in making the original soap, or to substances derived from the methylated spirit, it is difficult to say, but the experience of various specialists in skin diseases, as regards the effects of such soaps on persons possessing tender sensitive skins, is, I am informed by them, in exact conformity with the experience of my own friends, as just stated.

On the whole, it appears that there is much room for improvement in the general character of the toilet soaps in the British market, where good soaps, well made from sound materials, and devoid of free alkali, are far less numerous than articles inferior in some or all of these respects. To a great extent, however, the public has only itself to blame in the matter, inasmuch as (just as in many other instances) it persists in demanding articles to be supplied at prices incompatible with high quality, whilst it takes no pains to protect itself against the numerous frauds, adulterations, and misrepresentations thereby rendered inevitable, many of which would be punishable were toilet soaps and articles to come into the category of "food, drink, or drugs," so that penalties would attach to the selling of goods under false names, such goods "not being of the nature and quality demanded." It is true that no particular harm is done to the purchaser of a cake of "honey"* soap, should such soap contain no honey at all, as is usually (though not invariably) the case; but if an article is advertised as superior to others, and sold at an enhanced price, on the ground of its being said to contain certain ingredients which are not present at all (as for example in the case of soaps guaranteed to contain a high per-centage of glycerin, or advertised as specially suited for application

* A good grade of yellow soap retailed in bars at fourpence a pound, and containing, say, 67 per cent. of actual soap, represents sixpence per pound of actual soap; whilst, as regards alkalinity and quality of materials used in making, this soap is generally quite as good as even the best transparent soaps made without spirit, and far better than the lower kinds of such transparent soaps.

* Many of the so-called "honey" soaps sold owe their texture to extreme pearlashing, and consequently contain considerable amounts of free alkali, even when made from materials otherwise unobjectionable.

to the skin because sulphur is an ingredient, when in point of fact no trace of glycerin or of sulphur is present), it is evident that the purchaser is just as much "damnified" as he would be were he to purchase "bosch" butter, or oleomargarine, at the price of genuine cows' butter, or were skimmed or watered milk sold to him, instead of the unsophisticated article. That soap-makers do not look at the matter from this point of view, however, is evidenced by the fact that in the International Health Exhibition, not one, but several makers exhibited and supplied to the jury for analysis soaps stated to contain glycerin (in one case 30 per cent. being guaranteed), all of which were actually entirely devoid of that constituent, sugar being in some cases substituted for glycerin, in others not. Similarly, various other soaps were exhibited, professedly containing certain other ingredients, notably *milk*, *cream*, and *sulphur*, all of which were really conspicuous by their absence.*

During the course of these lectures I have been repeatedly asked "How is the general public to judge which soaps are really intrinsically good and safe to use even by sensitively skinned persons?" and also "How are manufacturers to know whetheir their soaps are imperfect in any important respect, so as to remedy the defect?" At a time when second and third rate articles are everywhere puffed and recommended from interested motives, the existence of a large demand is by no means necessarily a criterion of excellence; on the other hand, to satisfy the requirements of the public for cheapness, manufacturers are compelled to send out a large number of articles not so good in quality as they would be were the public at large willing to pay higher prices for superior makes. Naturally every one wishes to place his goods in the most favourable light before the public, and consequently it is not unusual in the soap trade, as in many other businesses, to obtain certificates of analysis for publication, so that the public may have some sort of guarantee of quality (apart from the maker's reputation). The fault in this system lies in the fact that an analysis of a single sample (possibly of superior quality selected for the purpose) affords no sort of guarantee that the goods supplied in quantity to the public are of the same quality as the specimen to which the certificate applies; and this is now so well understood that an analyst's certificate has come to be looked upon rather as an ordinary trade puff than as a genuine statement of the character of the goods as sold. To make such a document of any real value to the public it is requisite that the certificate should apply *not to a single sample sent for the purpose of obtaining a favourable report, but to the general character of the manufacture as deduced from frequent inspection and periodical examination of the materials in all stages of production.* Of course, the scientific position and general reputation of the analyst supplying the certificate requires to be also taken into account in determining how far the analytical report may be trusted as applicable to the goods as actually retailed. Until such time as the sale of soap, at any rate of toilet soaps, is put under the same kind of restrictions as those whereby the sale of unwholesome or adulterated food is attempted to be repressed, so that articles calculated to do injury to the skin or improperly described can only be sold at the risk of fine or other punishment, purchasers must be content either to find cut by trial which particular kinds of soap affect them unpleasantly, so as to eschew these for the future, or to purchase on the recommendation of some one competent to advise on the subject. As long, however, as copious advertising will attract numerous buyers, quite irrespective of the real nature of the goods puffed, so long will articles very far from first-rate in quality meet with a sufficiently ready sale to render their manufacture profitable, and so long, therefore, will such goods be continually pressed on the public attention. *Caveat emptor!* Let the purchaser beware!

* It is worthy of notice in this connection that so far as my own observations go, misrepresentations of this kind are far less common amongst Continental soap-makers; thus, I do not remember ever coming across a sample of so-called "glycerin soap" of Continental manufacture that did not actually contain at least some per cents. of glycerin.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The list of awards in the music division of the Exhibition were published in the *London Gazette* of Tuesday last. The Exhibition will be finally closed on Monday next, 9th inst.

Journal of the Society of Arts.

No. 1,721. Vol. XXXIII.

FRIDAY, NOVEMBER 13. 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

SOCIETY OF ARTS' MEDALS.

Three Gold Medals have been awarded by the Council of the Society of Arts to exhibitors in Division II. (Music) of the International Inventions Exhibition, on the recommendation of the Juries.

Group XXXII.

Messrs. John Broadwood and Sons.—For Pianos.
Messrs. Steinway and Sons.—For Pianos.
Messrs. W. E. Hill and Sons.—For Violins and Violoncellos.

These three medals were all offered under the Alfred Davis Trust.

INDIAN AND COLONIAL EXHIBITION.

His Royal Highness the Prince of Wales, President of the Indian and Colonial Exhibition, has approved of the *Journal of the Society of Arts* becoming the official organ of the Exhibition.

ARRANGEMENTS FOR THE SESSION.

The First Meeting of the One Hundred and Thirty-second Session of the Society will be held on Wednesday, the 18th November, when the Opening Address will be delivered by Sir Frederick Abel, C.B., D.C.L., LL.D., F.R.S., Chairman of the Council. Previous to Christmas there will be Four Ordinary Meetings, in addition to the Opening Meeting.

Candidates proposed for election as members are privileged to attend the Opening Meeting.

The following arrangements for the Wednesday evenings before Christmas have been made :—

November 18.—Opening Meeting of the Session. Address by Sir Frederick Abel, C.B., D.C.L., LL.D., F.R.S.

November 25.—"Apparatus for the Automatic Extinction of Fires." By Prof. Silvanus P. Thompson.

December 2.—"Technical Art Teaching." By F. Edward Hulme, F.L.S., F.S.A.

December 9.—"The Loadlines of Ships." By Professor Francis Elgar, LL.D., F.R.S.E., M.Inst.C.E.

December 16.—

At the meetings after Christmas the following papers (among others) will be read :—

"The Treatment of Sewage." By Dr. C. Meymott Tidy.

"Calculating Machines." By C. V. Boys.

"The History and Manufacture of Playing Cards." By George Clulow.

"Domestic Electric Lighting." By W. H. Preece, F.R.S.

"The Scientific Development of the Coal Tar Industry." By Prof. R. Meldola, F.C.S.

"The Experiments with Lighthouse Illuminants at the South Foreland." By E. Price Edwards.

Foreign and Colonial Section.

The Meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock :—

January 26; February 16; March 2, 23, April 13; May 18.

Applied Chemistry and Physics Section.

The Meetings of this Section will take place on the following Thursday evenings, at Eight o'clock :—

January 28; February 11, 25; March 11; April 8; May 13.

Indian Section.

The Meetings of this Section will take place on the following Friday evenings, at Eight o'clock :—

January 22; February 19; March 19; April 2; May 7, 21.

Cantor Lectures.

The First Course will be on "The Microscope." By John Mayall, Jun.

November 23, 30, December 7, 14, 21.

The Second Course will be on "Friction" By Prof. H. S. Hele Shaw.

January 18, 25; February 1, 8.

The Third Course will be on "Science Teaching." By Prof. F. Guthrie, F.R.S.

February 15, 22. March 1.

The Fourth Course will be on "Petroleum and its Products." By BOVERTON REDWOOD, F.C.S.

March 8, 15, 22, 29.

The Fifth Course will be on "The Arts of Tapestry Making and Embroidery." By ALAN S. COLE.

April 5, 12, 19.

The Sixth and Concluding Course will be on "Animal Mechanics." By B. W. RICHARDSON, M.A., M.D., F.R.S.

May 3, 10, 17, 24, 31.

JUVENILE LECTURES.

The Two Juvenile Lectures on "Waves" will be given by PROF. SILVANUS P. THOMPSON, D.Sc., on Wednesday evenings, December 30th, 1885, and January 6th, 1886. Special tickets will be issued for these lectures.

ANNUAL GENERAL MEETING.

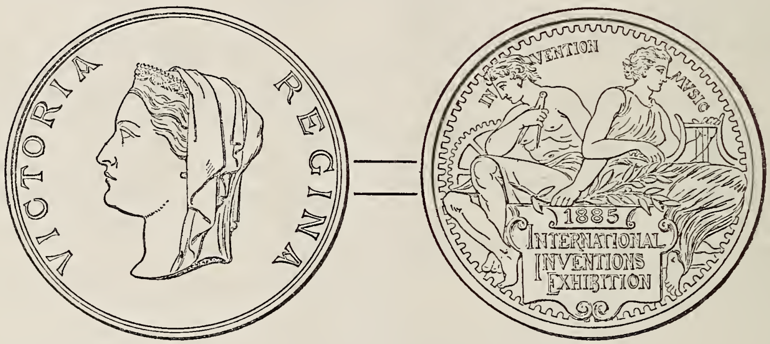
The Annual General Meeting will be held on Wednesday, June 30th, at Four o'clock.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

The Exhibition was closed on Monday, 9th inst. The number of visitors for the six months it has been open was 3,760,581; making a daily average of 23,071.

The annexed figure represents the design for the medals which has been chosen by the Executive Council.



INDIAN AND COLONIAL EXHIBITION, LONDON, 1886.

The Indian and Colonial Exhibition will form the fourth of the series of Exhibitions which is being held at South Kensington, under the presidency of H.R.H. the Prince of Wales.

It was in consequence of the greater importance of this Exhibition that his Royal Highness considered it desirable that application should be made to her Majesty for the appointment of a Royal Commission to organise it, and her Majesty was accordingly pleased to appoint a Royal Commission, and to nominate as its members those who have particularly identified themselves with the objects which it has been designed to promote. This Royal Commission was gazetted on November 18th, 1884; and on September 15, 1885, her Majesty was pleased to issue letters patent making the Commission a body corporate under the name of the "Indian and Colonial Exhibition Commissioners, 1886."

Immediately after the Commission had been gazetted, his Royal Highness, as President, addressed a dispatch to the various Colonial Governments and to the Secretary of State for India, in which his Royal Highness stated that he was desirous "that this Exhibition should be the means of bringing prominently under notice the development and progress which have been made in the various parts of the British Empire, trusting that a more intimate knowledge may thus be obtained of the vast fields for enterprise which exist throughout the British Dominion." With this dispatch was forwarded to each Government a plan of the Exhibition, showing the space which the Royal Commission had decided to set apart for it; and the dispatch also contained the suggestions which his Royal Highness was pleased to make as to the best means of organising the various departments of the Exhibition.

The guarantee fund at the present amounts to £199,670—an amount far in excess of that of any Exhibition which has been held during the last few years.

The courts facing the main entrance in the Exhibition-road, known as the South Galleries, have been allotted to India and Ceylon; Australia has received the block of buildings in the immediate centre of the Exhibition which has at the previous Exhibitions been occupied by foreign nations; and it may be here mentioned that by erecting a new gallery between these courts and the Central Gallery, it has been found possible to accede, in a limited way, to the pressing requests for more space made by several of the Australian Colonies. The Central Gallery, opening into the upper gardens, has been given to the Dominion of Canada, which will also occupy the greater portion of the Western Gallery, hitherto devoted to machinery in motion; that portion of the Western Gallery not occupied by Canada has been allotted to New Zealand. The Eastern Gallery is divided among the West Indian Colonies, British Guiana, and Hong Kong, which colony will occupy the space hitherto known as the Chinese Court. In the Queen's Gate Annexe, at the west entrance of the Exhibition, will be found the various African colonies, while the Mediterranean colonies are placed in the Eastern Annexe. The East Arcade and the Quadrants have been allotted among various smaller applicants; and a large portion of the Aquarium will be devoted to a display of Colonial and Indian fish. It will thus be seen that the whole of the Exhibition buildings will be occupied by the allotments already made, and, indeed, there are but few colonies—and those very small ones—which have not either received space or signified their inability to exhibit. Among these latter colonies are Newfoundland and Tasmania.

The "Old London Street" will be left standing. Opposite the entrance, and on the site of the Prince of Wales Pavilion—which is to be removed—is to be erected an Indian palace.

It may be noted, with special reference to the Colonial side of the Exhibition, that due prominence will be given to the proper display of colonial wines, &c., and arrangements have been made for utilising the basement of the Royal Albert Hall, which, as in previous years, will form an integral part of the Exhibition. Here it will be possible to give ample cellarage accommodation to the various wine-producing colonies. The public will be admitted to these rooms, and special regulations are being framed for the tasting of wines by intending purchasers. Special bars will also be erected in the courts of the more important wine-producing colonies for a similar purpose, and equal prominence will be given to the display and tasting of colonial teas, coffees, cocoas, and tobaccos.

The total area of the Indian Section of the Exhibition will be not less than 65,000 square feet, and this space will be so allotted as to enable the visitor, whether a pleasure-seeker or a student, to obtain a thorough and comprehensive view of the physical aspect, natural productions, and arts and manufactures of our vast Indian Empire. On entering the Exhibition he can first visit the space devoted to the illustration of the mode in which India is governed, and here each administrative department of the Government will show, by maps, Blue-books, diagrams, and statistics, what useful work it carries out. Adjoining will be a reproduction of a jungle scene, with lifelike figures of the principal wild animals and showy game birds of India, which Mr. Rowland Ward is preparing for the Royal Commission.

The southernmost gallery of the present Exhibition buildings will be entirely given up to an Imperial Economic Court, in which the natural mineral and vegetable wealth of the country, as well as its principal productions and rougher manufactures, will be exhaustively illustrated. This section will be of special interest to all who are concerned in commerce, as each province and port will send a collection illustrating their principal articles of export, and such staples as jute, indigo, cotton, wheat, timber, &c., will be prominently set forth. In the same gallery will be shown objects of ethnological interest—such as dressed figures of natives, models, and agricultural scenes.

The more popular illustration of Indian arts and manufactures will be found in the courtyard of the great Durbar Hall, which will take the place of the Prince of Wales pavilion of former years.

The shops and the great hall are being constructed by native workmen from Punjab, who, since midsummer, have been working in the grounds of the Exhibition in preparing and fitting the carvings. The shops will be peopled by native artificers and merchants, such as are found within the precincts of the great palaces and temples in India; and as the presence of several of the Indian princes and the native chiefs is expected, it is probable that on many occasions a magnificent spectacle of Oriental splendour will be realised.

The Royal Commission intends to devote special attention to the consideration of the most suitable steps for spreading a knowledge of Indian teas, coffees, and tobaccos, and a considerable area will be devoted to a complete collection of samples of tea and coffee from every Indian estate, while at the same the sale of tea in packets, as well as by the cup, and the tasting of tea samples will be arranged for. The use of Indian cigars in this country has increased considerably of late years, and every opportunity will be given at the Exhibition for visitors to become acquainted with the best varieties of cigars and tobaccos; a space will also be devoted to showing the great progress made in recent years in the utilisation of the tusser and other wild silks of India.

In the galleries of the Royal Albert Hall, it is proposed to arrange a collection of portraits of the various native princes, as well as pictures illustrating the scenery, architecture, and customs of India, and the numerous loan collections of interesting objects which have already been most generously offered by private individuals will also probably be located here.

Sir Philip Cunliffe-Owen, in replying to the toast of his health, at the banquet given in his honour at the Empire Club, on the 5th inst., said the whole of the space of the Exhibition was allotted very shortly after the Royal Commission was issued last November. His Royal Highness, in communicating this decision to the various colonies, informed them that every effort had been made to meet the requirements of the colonies, as far as room was available for giving each colony sufficient space. He believed that in the month of January last, when the different legislative assemblies of those various Governments met, they heartily responded to the invitation of the Heir Apparent of the Crown, and voted sums of money, and gave all their energies to support the movement put forward by the Prince of Wales. There was a great deal of ignorance on the part of the public with regard to the colonies, and therefore his Royal Highness had authorised him to address to the mayors of the United Kingdom, even at this early date, a request that they will form workmen's clubs, to which the working classes can subscribe small sums during the winter, to enable them to visit the Exhibition when it opens in May.

INSECT PESTS OF INDIA.

The following correspondence has been forwarded to the Secretary by the Secretary of State for India for publication:—

From Surgeon-General Edward Balfour to the Under Secretary of State for India.

2, Oxford-square,
Hyde-park, London,
8th August, 1885.

SIR,—The article "Insects" in the 3rd edition of the "Cyclopædia of India and of Eastern and Southern Asia," is, I think, the first attempt to give a general view of the entomology of that wide region. This is, in many ways, a very difficult branch of natural history; but this article was prepared and printed by me under the care of two scientific men, one of them ranking among the most learned of living entomologists, and I was favoured also with counsel from Miss Ormerod, who, in this country, annually reports on the insects injurious to food crops, forest trees, and fruits and the prevention of insect ravages.

The like of Miss Ormerod's form of reporting has never been done for India. Although every year, to some extent, and from time to time largely, losses occur there from the pests which attack agricultural produce, India has hitherto been remiss in this matter, contenting itself with references as to individual insect or blights to such persons as were thought likely to be able to give information. But the subject is of far too great importance to agricultural India to be left to be treated in so casual a manner, and the special knowledge now available might be utilised to describe the insects which injure the agricultural, horticultural, and forest produce of India, suggesting means of preventing, and remedies for same.

The reports should be restricted rigidly to the injurious insects, and should be half-yearly, to fit in with the two great agricultural seasons.

I have, &c.,
(Signed) EDWARD BALFOUR,
Surgeon-General.

To Surgeon-General Edward Balfour, 2, Oxford-square, Hyde-park, W.

India-office,
24th September, 1885.

SIR,—I am directed by the Secretary of State for India in Council to acknowledge with thanks your letter of the 8th ultimo, with reference to the preparation of official annual reports on the insects destructive to crops and forests in India; and to inform you in reply that a copy of it has been forwarded to the Government of India.

I am, &c.,
(Signed) HORACE WALPOLE.

To Horace Walpole, Esq., C.B.

2, Oxford-square, Hyde-park, W.,
28th September, 1885.

DEAR SIR,—I sent to Miss Ormerod copy of my letter of the 8th August, and copy of the Secretary of State's letter of 24th instant in reply.

I enclose, now, copy of the acknowledgment of these which Miss Ormerod has written to me.

I beg the favour of your submitting to Her Majesty's Secretary of State that if this correspondence could be printed and circulated from here, all the entomologists and their entomological societies in all Europe could aid in this very important investigation. There are only a very few in India. I have no doubt but that I could distribute usefully 200 copies.

I am, &c.,
(Signed) EDWARD BALFOUR.

To Surgeon-General Edward Balfour, 2, Oxford-square, W.

Dunster-lodge,
Spring-grove, Isleworth,
September 25th, 1885.

DEAR MR. BALFOUR,—I am very much obliged to you for favouring me with a copy of your letter to the Under-Secretary of State for India relative to the importance of acquiring serviceable information regarding the injurious crop insects of India, and also kindly giving me a copy of the official reply.

I do not see that you could do better, as a commencement, than thus bring the subject shortly and clearly forward; and, as far as I can form an opinion, I think that the course you suggest would be the constant means of saving thousands of pounds yearly

—occasionally (perhaps more than occasionally) of saving millions. I found this opinion, of course, on consideration of the unremunerative outlay so often occurring on some of the great crops, notably (as coming specially under my notice) the loss by ravage of coffee-plant grubs.

The information that is needed could be given by plain and simple jotting down by various persons of what they themselves have observed.

One man notices, perhaps, how deep the grubs go; another, how long they live; and so, by collating the points, we get to know the whole history of habits, which is what is needed to work on. It may take a few years to get the whole life history of the insects, but we soon get in the way mentioned above (on which plan my own reports are formed) to learn the main points, and then all observers are requested to find the missing part of the history.

If reports were formed in this way, there would very shortly be a great increase of useful knowledge throughout the Indian empire.

I present my reports yearly to the contributors, thus they take a personal interest in the work, and, what is immensely important in things of this kind, the book comes to them on publication; they have not the trouble of ordering it. The expense would be a mere nothing to Government, seeing that I, a private individual, have now for eight years, without the slightest assistance, carried on the work in England.

The great mistake is in waiting until attack is unusually destructive, and then consulting those who, though eminently sklled in classification of insects, have no idea, or well founded knowledge of the points of agricultural treatment or forestry which must be brought to bear on the insects in some special stage of their life. Likewise (as occurred not long ago) to advise reliance on the insectivorous animals of England for help in India or Ceylon is a decided mistake.

If, from the long experience which I have now had of gaining information on insect attacks and forming it into readable shape, you think any suggestions on my part would be of service, I should be most happy to give any attention in my power to the subject. But, meanwhile, I may most truly say that if the crop, or timber, or fruit growers of India were furnished with plain and comprehensive accounts of the history and habits of the common insect pests, accompanied by woodcut figures, so as to convey the appearance of the pests without wearisome descriptions of details, that all this would be a national benefit, soon paying the outlay hundreds of times over.

With renewed thanks, I am,
Dear Mr. Balfour, yours very truly,
(Signed) Eleanor A. Ormerod.

P.S.—Pray make any use you may think fit of this; it will give me pleasure for it to be of any service.
(Signed) E. A. O.

To Surgeon-General E. Balfour, M.D., 2, Oxford-square, Hyde-park, W.

India-office,
4th November, 1885.

Sir,—I am directed by the Secretary of State for India in Council to acknowledge with thanks the receipt of your letter of 28th September last, enclosing an interesting communication from Miss Ormerod on the subject of the insect pests of Indian crops and forests. In reply, I am to inform you that a copy of this correspondence has been forwarded to the Government of India; and that another copy of it, and of your previous letter of the 8th August last, has been sent to the Society of Arts, for publication in their widely circulated *Journal*.

I am, sir,
Your obedient servant,
(Signed) J. A. Godley.

GRAPE CULTIVATION IN ZANTE.

The United States Consular agent at Zante, says that raisins, such as are generally known by this term, are not prepared in Zante, though many varieties of the grape grow in profusion in the island. The currant grape was originally imported by refugees from Corinth in the year 1530. It is a small purple grape, free from seeds, and now forms the staple production of the island. The position of the vineyards is mostly on the plains bordering the sea-coast, at the foot of a wooded hill, the deposits from which enrich the soil below it. Although many vineyards extend down to the sea, the plants within 500 or 1,000 yards of it are liable to suffer. The yield, value, and cost of the crop per acre varies according to the soil, cultivation, and other conditions. A good average crop is considered to be 260 pounds of fruit per *axinari*, or 2,083 pounds per acre; the average value is about £12 per acre, and the cost of the crop in cultivation is about £4 per acre. The average annual yield of currants is estimated to be about 7,000 tons, the acreage under cultivation being over 10,000 acres, but this extent is rapidly increasing, many olive groves being rooted up to make room for the currant plant. Besides the "currant" grape, there are sixty or seventy varieties of the grape grown in the island, of which only about seven or eight are cultivated for wine making, the remainder being for eating purposes. The vineyards producing the best wines are mostly on hillsides, on light, shallow, and stony soils. In some cases grapes have been grown in a soil entirely of sand, near the sea, which have produced excellent wine, though the yield is small. A very superior quality of both white and red wine is made in Zante, resembling the best full-bodied Sicilian, and in some cellars an imitation of sherry and port is to be found. The cultivation of both the currant and wine grape is very similar to that practised in France, only that

the system of low cultivation prevails, no plant exceeding four feet in height. Owing to the difference of climate, the various processes are somewhat earlier than in France, and the currant has the attention of the grower before the other vines. The fruit of the former is ready in the latter part of July or beginning of August, when the branches are gathered and laid out on carefully prepared drying grounds, which have been previously besmeared with a coating of cows-dung liquefied in water, or in wooden trays, and they remain exposed for eight or ten days, according to the powers of the sun's rays. They are then cleared with a light broom from the stalks, heaped together for about twenty-four hours, and finally passed through a winnowing machine, and are then ready for market. The vintage of the wine grape commences the latter part of September. If an extra sweet wine is required, the grapes are exposed to the sun for three or four days after being gathered, before they are pressed.

INSTITUTE OF CHEMISTRY.

The anniversary meeting of the Institute of Chemistry was held on Friday last, at the rooms of the Chemical Society, Burlington-house, this being the first anniversary since the Institute has obtained its charter. Up to the present year the members have, since 1877, been incorporated under articles of association in accordance with the provisions of the Companies' Act (1867). Prof. Odling, F.R.S., the President, in his address, spoke of the increasing demand there is for professional chemists in Government departments, municipal and other corporations, and by large manufacturing firms. The aim of the Institute is to raise the standard of knowledge possessed by professional chemists by the examination of candidates for the associateship of the institute (as a preliminary to fellowship), and also to raise the dignity of the profession in public estimation. He claimed that the practical work of the professional chemist was as worthy of respect as that of the theorist who devotes himself to research. The idea "that there is something derogatory to the man of science in making his science subservient in any way to the requirements of his fellows, and thereby contributory to his own means of support of himself and those depending upon him," he repudiated, and adverted to the fact that nearly all the distinguished men who have advanced the science of pure chemistry have been practical men, and their services have been employed on questions of public utility. It was a mistake to suppose that "investigations, however creditably conducted, are to lift their authors into a scientific position altogether above that of men whose laborious lives have been spent in rendering their great scientific attainments directly available to the needs of the State and of the community." Referring to the question of the endowment of research, it was urged that the best of all endowments for research is unquestionably that with which the searcher, relying on his own energies, succeeds in endowing himself. As regards the future reputation of the Institute, each should strive to promote it by his own individual character and conduct; by the soundness of his professional work.

The vote of thanks was proposed by Professor Frankland, and seconded by Sir Frederick Abel, both past presidents of the Institute.

Correspondence.

COMMERCIAL GEOGRAPHY.

While there is steady increase in the number of our candidates for examination in some departments of commercial knowledge, there has been a falling off in modern languages, and in commercial geography and history. As an examiner in the last two subjects, may I offer a few remarks on them chiefly?

Our experience corresponds with that of the Royal Geographical Society, and of provincial associations. In spite of many efforts by scientific men, by travellers, and by Chambers of Commerce, the study does not progress as it ought to do; for our age is marked by the extension and multiplication of means of intercourse between nations; and commercial geography pre-eminently shows both the natural and the artificial bonds of union, available or prospective. It lays no great stress on what is long or short, measured by geographical miles; it judges by the test of convenience and practicability; it proves that true nearness consists in ease of passage from land to land, and true distance in difficulty of communication. It is in harmony with the age.

The "Commercial Sciences" combined account for the mutual relations of places and products. The Historical explain the sequence of events, and point out the main motor-forces of demand and supply. With every stage of social progress changes occur in industrial systems. Men become better fitted to use their resources; commercial security is raised, hence international credit grows; higher civilisation promotes closer interdependence. But everywhere *internal changes* occur before new mercantile wants appear. Alterations in the markets are seldom remodellings from external pressure; rather they result from slow growth within, and require to be watched. Trade is not confined to the necessaries of life. It depends more largely on the varied products or educts of national existence. There are zones of intellectual to culture be studied, no less than climatic zones. Levasseur says the history of industry and commerce is as important as political economy, which it illustrates and popularizes. Why is it

neglected, and what can be done further to advance it? Ought our universities to ignore it?

These questions seem to me of the greatest moment in view of "Imperial Federation," so much discussed, and of the coming Indian and Colonial Exhibition in 1886. Without increased attention to commercial geography and history, are we likely to rise to a conception of a "common federal citizenship," or to find that common career which is hinted at, for every British subject?

JOHN YEATS.

Chepstow, 28th October, 1885.

Obituary.

DR. W. B. CARPENTER, F.R.S., died at his residence in London on Tuesday, 10th inst. His health had been failing for some time, but the immediate cause of his death was the overturning of the lamp of a vapour-bath, by which accident he was severely burnt. William Benjamin Carpenter, son of Dr. Lant Carpenter, was born at Bristol in 1813. He took the degree of M.D. at Edinburgh in 1839, and after practising his profession for a short time he came to London, and devoted himself to the cultivation of physiology. He became Professor of Medical Jurisprudence in University College and Examiner in Physiology and Comparative Anatomy in the University of London. In 1856 he was appointed Registrar of the University of London, an office he held for twenty-two years. It was chiefly to Dr. Carpenter's exertions that the series of deep sea dredging expeditions, which culminated in the voyage round the world of the *Challenger*, was commenced, and he devoted his chief energies to the consideration of the results of these expeditions. His works on physiology and on the microscope have gone through many editions. Dr. Carpenter was elected a life member of the Society of Arts, in 1856, by the Council, in consideration of the valuable assistance he afforded to the Society when medals were awarded, in 1855, for microscopes to be sold to the public at a cheap rate.

General Notes.

COTTON GROWING IN CENTRAL ASIA.—A Russian journal states that marked success has attended the efforts made to introduce the growing of cotton in the Merv district. The plant has been pronounced to be quite equal to the Transatlantic article. This year's crop has been sufficiently abundant to allow the inhabitants of Merv to make a sending of cotton to Askhabad. Attention is likewise being paid in the Caucasus provinces to trials in raising cotton.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, Nov. 16...Geographical, University of London Burlington-gardens, W., 8½ p.m. 1. Opening Address by the President. 2. Mr. Holt S. Hallett, "Exploration-Survey for a Railway Connection between India, Siam, and China."

British Architects, 9, Conduit-street, W., 8 p.m. Mr. W. Woodward, "London as it is and as it might be."

TUESDAY, Nov. 17...Civil Engineers, 25, Great George-street, 8 p.m. Adjourned discussion on (1) Prof. Osborne Reynolds's paper, "The Theory of the Indicator, and on the Errors in Indicator-Diagrams;" (2) Mr. A. W. Brightmore's paper, "Experiments on the Steam-engine Indicator."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m. Opening Address by the President, Sir Rawson W. Rawson, "International Statistics, Illustrated by Vital Statistics of Europe, and of some of the United States of America."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. F. E. Beddard, "Notes on the Visceral Anatomy of Birds.—Part I. The so-called Omentum." 2. Mr. J. S. Sutton, "The Origin of the Urinary Bladder." 3. Mr. O. Thomas, "The Rodent Genus *Heterocephalus*."

WEDNESDAY, Nov. 18...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Opening Address by Sir Frederick Abel, Chairman of the Council.

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. William Marriott, "The Helm Wind of August 19th, 1885." 2. Mr. Henry Harries, "The Typhoon Origin of the Weather over the British Isles during the 2nd of October, 1885." 3. Messrs. J. B. Jordan and F. Gaster, "Note on the the Principle and Working of Jordan's Improved Sunshine Recorder."

Geological, Burlington-house, W., 8 p.m. 1. Dr. Henry Hicks, "Results of recent Researches in some Bone-caves in North Wales (Cae Gwyn and Fynnon Beuno)." 2. Mr. R. Lydekker, "Description of the Cranium of a new Species of *[illegible]* from the Upper Miocene of Œningen." 3. Mr. R. Lydekker, "The Occurrence of the Crocodilian Genus *Tomistoma* in the Miocene of the Maltese Islands." 4. Mr. G. Waring Ormerod, "Old Sea-beaches at Teignmouth, Devon."

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. W. de Gray Birch, "The Art of the Roman Pavements at Bignor." 2, Mr. C. H. Compton, "Notes on the Church of St. Nicholas, Coslany, Norwich." 3. Mr. John Harris, "The Saxon Font in South Hayling Church."

Patent Agents, 55, Chancery-lane, W.C., 7½ p.m. Mr. C. D. Abel, "Certain Peculiarities in German Patent Procedure."

THURSDAY, Nov. 19...Linnean, Burlington-house, W., 8 p.m. 1. Prof P. M. Duncan, "The Perignathic Girdle of the Echinoidea." 2. Mr. Geo. C. Bourne, "Anatomy of *Sphærotherium*." 3. Mr. A. D. Michael, "Immature Stages of *[illegible] cœpheiformis*."

Chemical, Burlington-house, W., 8 p.m. 1. Dr. Gladstone and Mr. Tribe, "Aluminium Alcohols. Part III. Aluminium Orthocresylate and its Products of Decomposition by Heat." 2. Mr. S. U. Pickering, "Notes on the Constitution of Hydrated and Double Salts." 3. Mr. J. T. Brierley, "Some Vanadium Compounds."

FRIDAY, Nov. 20...Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. John Goodman, "Recent Researches in Friction."

CONTRIBUTIONS TO THE READING-ROOM.

The Council beg leave to acknowledge, with thanks to the Proprietors, the regular receipt of the following Transactions of Societies and Periodicals during the year.

TRANSACTIONS, &c.

Académie des Sciences, Comptes rendus hebdomadaires.
Aeronautical Society, Annual Report.
American Chemical Society, Journal.
American Philosophical Society, Transactions.
American Society of Civil Engineers, Transactions.
Art Union of London, Report.
Association of Engineering Societies, Journal.
Bath and West of England Society, Journal.
Bayerische Dampfkessel-Revisions-Verein, Bayerisches Industrie-und-Gewerbeblatt.
Berlin, Verhandlungen der Polytechnischen Gesellschaft.
British Association for the Advancement of Science, Report.
British Horological Institute, Journal.
Chemical Society, Journal.
Chemico-Agricultural Society of Ulster, Journal.
East India Association, Journal.
Farmers' Club, Journal.
Franklin Institute, Journal.
Gas Institute, Transactions.
Geological Society, Quarterly Journal.
Geologists' Association, Proceedings.
Glasgow Philosophical Society, Proceedings.
Index Society, Publications.
India, Geological Survey of, Memoirs, Records, and Palæontologia Indica.
Indian Meteorological Memoirs.
Institute of Bankers, Journal.
Institute of Patent Agents, Transactions.
Institution of Civil Engineers, Minutes of Proceedings.
Institution of Civil Engineers of Ireland, Transactions.
Institution of Engineers and Shipbuilders in Scotland, Transactions.
Institution of Mechanical Engineers, Proceedings.
Institution of Naval Architects, Transactions.
Iron and Steel Institute, Journal.
Linnæan Society, Journal.
Liverpool Literary and Philosophical Society, Proceedings.
Liverpool Polytechnic Society, Journal.
Lyons, Société des Sciences Industrielles, Annales.
Manchester Literary and Philosophical Society, Memoirs.
Manchester Steam Users' Association, Monthly Report.
Musée de l'Industrie de Belgique, Bulletin.
National Association for the Promotion of Social Science, Sessional Proceedings.
National Indian Association, Journal.
Pharmaceutical Society, Journal and Transactions.
Philadelphia, Academy of Natural Sciences, Proceedings.
Philadelphia, Engineers Club of, Proceedings.
Photographic Society of Great Britain, Journal.
Physical Society of London, Proceedings.
Quekett Microscopical Club, Journal.
Rome, Giornale del Genio Civile.
Royal Agricultural Society, Journal.
Royal Asiatic Society, Journal.
Royal Astronomical Society, Memoirs.
Royal Colonial Institute, Proceedings.
Royal Cornwall Polytechnic Society, Report.
Royal Geographical Society, Proceedings and Journal.
Royal Institute of British Architects, Journal of Proceedings and Transactions.
Royal Institution, Proceedings.
Royal Irish Academy, Transactions and Proceedings.
Royal Meteorological Society, Quarterly Journal.
Royal National Life Boat Institution, "The Life Boat."
Royal Scottish Society of Arts, Transactions.
Royal Society, Proceedings and Philosophical Transactions.
Royal Society of Edinburgh, Proceedings and Transactions.
Royal United Service Institution, Journal.
Schlesische Gesellschaft für vaterländische Cultur, Jahres Bericht.
Société d'Encouragement pour l'Industrie Nationale, Bulletin.
Société Nationale d'Acclimatation de France, Bulletin Mensuel.
Society of Antiquaries, Archæologia and Proceedings.
Society of Biblical Archæology, Transactions and Proceedings.
Society of Chemical Industry, Journal.
Society of Engineers, Transactions.
Society of Telegraph Engineers and Electricians, Journal.

South Wales Institute of Engineers, Proceedings.
Statistical Society, Journal.
Victoria Institute, Journal of the Transactions.
Württemburg, Königliche Centralstelle für Gewerbe und Handel, Jahresberichte.
Zoological Society, Proceedings and Transactions.

PERIODICALS.

Twice a Week.

Chemiker-Zeitung.
Commissioners' of Patents Journal.

Weekly.

Admiralty and Horse Guards Gazette.
Agricultural Gazette and Dairy Farmer.
Amateur Photographer.
American Architect and Building News.
American Pottery and Glassware Reporter.
Architect.
Athenæum.
Bradstreet's.
British Architect and Northern Engineer.
British Journal of Photography.
Builder.
Builders' Weekly Reporter.
Building and Engineering Times.
Building News.
Chemical News.
Colliery Guardian.
Colonies and India.
Cosmos ; Revue des Sciences.
Country Brewers' Gazette.
Draper.
Electrician.
Electricité.
Empire.
Engineer.
Engineering.
English Mechanic.
European Mail.
Farmer and the Chamber of Agriculture Journal.
Gardeners' Chronicle.
Gardening World.
Gas and Water Review.
Herapath's Railway Journal.
Invention and Inventors' Mart.
Iron.
Iron and Coal Trades Review.
Ironmonger.
Journal of Gas Lighting.
Journal d'Hygiène.
Land and Water.
London Iron Trade Exchange.
Mechanical World.
Medical Press and Circular.
Metropolitan.
Miller.
Millers' Gazette.
Mining Journal.
Moniteur Industriel.
Mouvement Industriel Belge.
Musical Standard.
Musical World.
Nature.
Orchestra Musical Review.
Photographic News.
Photographic Times and American Photographer.
Produce Markets' Review.
Queen.
Revue Industrielle.
Sanitary Engineer.
Sanitary Engineering.
School Board Chronicle.
Schoolmaster.
Scientific American.
Society.
Statist.
Telegraphic Journal and Electrical Review.
United States Patent Office, Official Gazette.
Warehousemen and Drapers' Trade Journal.
Wool and Textile Fabrics.

Quarterly.

Asclepiad.

Fortnightly.

American Gas Light Journal.
Brewers' Guardian.
Corps Gras Industriels.
Finance Chronicle.
Gaceta Industrial.
Irish Builder.
Jeweller and Metalworker.
Monde de la Science et de l'Industrie.
Moniteur des Produits Chimiques.
Planters Gazette and Commercial News.
Publishers' Circular.

Monthly.

American Journal of Science.
Analyst.
Antiquary.
Art Journal.
Artist.
Bookseller.
Brick, Tile, and Metal Review.
British Mail.
British Mercantile Gazette.
British Trade Journal.
Building Societies' and Land Companies' Gazette.
Building World.
Cabinet Maker and Art Furnisher.

Canadian Patent Office Record.
Caterer and Refreshment Contractor's Gazette.
Chemist and Druggist.
Dental Record.
Dyer.
Educational Times.
Electrical Engineer.
Furniture Gazette.
Gas Engineer.
Health Journal.
Illustrated Science Monthly.
Inland Architect and Builder.
Journal of Science.
Knowledge.
Leather Trades' Circular and Review.
Machinery Market.
Magazine of Art.
Manufacturer and Builder.
Manufacturers' Review and Industrial Record.
Marine Engineer.
Martineau & Smith's Hardware Trade Journal.
Midland Naturalist.
Mineral Water Trade Review and Guardian.
Moniteur Scientifique.
Nautical Magazine.
Oesterreichische Monatsschrift für den Orient.
Paper Makers' Circular.
Paper Makers' Monthly Journal.
Phœnix.
Plumber and Decorator.
Pottery Gazette.
Saddlers, Harness Makers, and Carriage Builders' Gazette.
Sanitary Record.
Sugar Cane.
Symons's Meteorological Magazine.
Textile Manufacturer.
Textile Recorder.
Textile World.
Watchmaker, Jeweller, and Silversmith.

Two-Monthly.

Coach Builders', Harness Makers', and Saddlers' Art Journal.

NEWSPAPERS.

Belgian News.
Bombay Gazette, Overland Summary.
Ceylon Observer & Weekly Summary of Intelligence.
Ceylon Times, Weekly Summary.
Eastern Post.
Home and Colonial Mail.
London Commercial Record.
London and China Telegraph.
Nottinghamshire Guardian.
Sheffield and Rotherham Independent.
Times of India (Overland Weekly Edition).
West London Observer.

INDEX TO VOL. XXXIII.

A.

B.

C.

N.

O.

P.

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